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Montana Air Resources Modeling System
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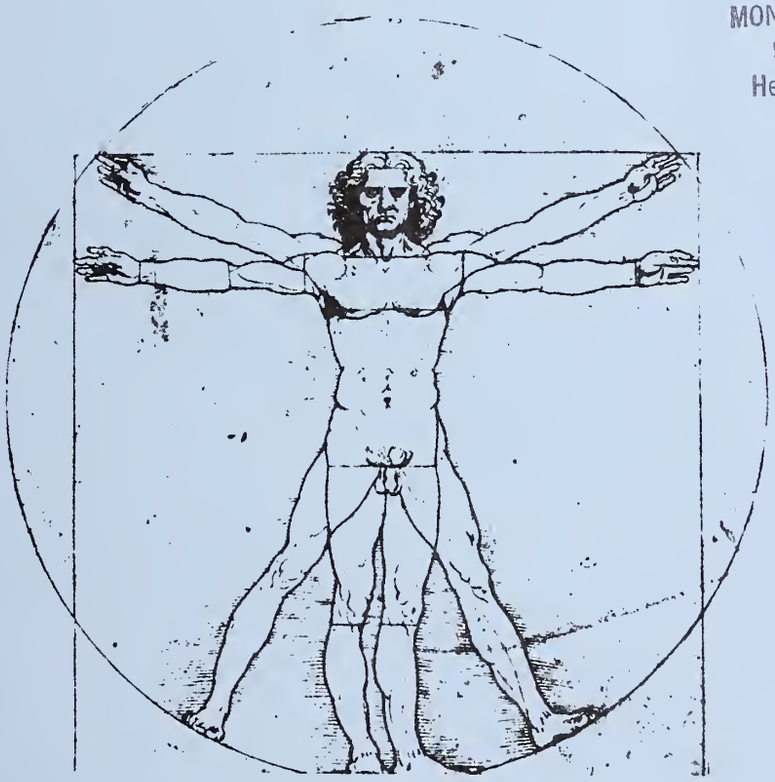

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MONTANA AIR RESOURCES MODELING SYSTEM

by

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and

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MONTANA AIR POLLUTION STUDY

AIR QUALITY BUREAU

ENVIRONMENTAL SCIENCES DIVISION
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PREFACE

This is one of a series of technical reports presenting results from the Montana Air Pollution Study (MAPS), a special air monitoring and health effects project of the Air Quality Bureau of the Montana Department of Health and Environmental Sciences. The MAPS program was funded by the 1977 Montana Legislature with $1.07 million for the 1977-79 biennium to improve understanding of the effects of air pollution on human health.

The various activities undertaken as part of the MAPS effort have been grouped into five major categories for purposes of project management: Health Effects, Air Quality, Meteorology/Modeling, Emission Inventory, and Statistics and Data Systems. Each of these technical areas will generate one or more technical reports prepared by the personnel directly involved in the study efforts. There also will be a summary report in two versions, one technical for the use of professionals in the field, and one in layman terms for the public.

EXECUTIVE SUMMARY

This report describes the Air Resources Modeling System (ARMS) developed under the Montana Air Pollution Study. The system integrates a series of computer simulation air quality models with two data systems which handle emission data and air quality and meteorology data. The data systems and the work performed to modify the systems to accept data collected in Montana are described. Also described are the diffusion models and the accompanying input data compilation programs. The ARMS represents a significant step forward in developing a modeling system that can be used with a high degree of confidence in reviewing new or modified air pollution sources. The new modeling system will benefit all areas of Montana in providing a more efficient and accurate prediction of air quality impacts likely to result from a given pollution source. The majority of the computer work was performed by Thomas Stewart, P.E. The modeling system was designed and the installation coordinated by James Gelhaus, meteorologist with the Air Quality Bureau.

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INTRODUCTION

One of the functions of the Air Quality Bureau (AQB) of the Montana Department of Health and Environmental Sciences is the review of new or modified air pollution sources proposed for construction in Montana. Knowledge on the probable emission levels of proposed new sources can be obtained from similar plants operating in other states, but ambient pollution levels are determined by local influences such as elevated terrain and meteorology. In order to estimate the concentrations of air pollutants likely to result from the operation of any proposed new plant in Montana, computer simulations models (called diffusion models because of the physical process simulated) are constructed for each proposed new or modified plant. The diffusion models attempt to simulate the physical plant design and the diffusion of the air pollutants emitted. Information on such variables as meteorology, topography, and background air quality is needed to accurately simulate the environment around the plant. Topography information is usually obtained from United States Geological Survey (USGS) maps. Background air quality is usually measured prior to submission of the permit application. This leaves meteorology as the only unknown influence on ambient pollution levels in the plant vicinity. Past modeling efforts have relied heavily on weather observations made by the National Weather Service (NWS) at airports. These data are primarily related to surface meteorological conditions. Upper air meteorology conditions are measured by the NWS at key locations throughout the country. However, the great expense of operating these stations and their primary use in tracking

large weather systems results in their being located far apart. There are only two such stations in Montana, one in Great Falls and the other in Glasgow. Another problem with the NWS upper air measurements is that the stations are located away from complex terrain (such as western Montana) which can make the large scale picture that much harder to interpret. Because of these limitations NWS data are often not sufficient to describe the meteorological conditions affecting air pollution in a given area.

As part of the Montana Air Pollution Study (MAPS), meteorological data relating to surface and upper air conditions were collected in various places in Montana. Data also were obtained from other studies and ambient monitoring programs. These data were essential to any diffusion modeling attempted in any of the areas where data were collected. However, since few states conduct such large scale meteorological studies, the diffusion models used (obtained already written from the Environmental Protection Agency) were designed to accommodate NWS data. The models therefore had to be revised to accept local meteorological data.

This report discusses the assembly of the ARMS for Montana. The various input data and the models used are discussed.

II. DATA PROCESSING SYSTEM

The three primary types of data required by any diffusion model are the background air quality levels, the air pollution source emission parameters, and the local meteorology. In an effort to save time and money, existing computer data systems were modified to suit the needs of ARMS. However, as will be discussed, the meteorological data required a great deal of effort to prepare it for use by the computer.

A. Emission Data System

The AQB for several years has been operating a data system called the Emission Inventory Subsystem/Permits and Registration (EIS/P&R). The system was obtained from the Environmental Protection Agency and stored in the Montana Department of Administration IBM-370 computer. The system is a complex series of computer programs allowing addition, change, or deletion of information relating to all major air pollution sources in the state. The system creates a master file on the description, location, physical design, and operating characteristics of the plants. Plant characteristics are broken into segments, relating to individual points within a plant and to an even lower level of machine processes within a point. Information included in this file is the location of the source and the emission parameters such as emission rates, stack heights and diameters, and exit gas temperatures and velocities. Very little work was needed to modify the EIS/P&R system to suit the needs of ARMS. However, the AQB is proposing to modify EIS/P&R in the future to

better handle large area emissions and to prepare more meaningful summary reports from the data for internal AQB use.

B. Air Quality Data System

Air quality data presently is handled in the AQB by the Air Quality Data Handling System (AQDHS). This system also was obtained through the Environmental Protection Agency and stored on the Montana Department of Administration's computer. The system is a complex set of computer programs which allows data to be added, changed or deleted; produces summary reports; edits and performs some quality checks; and keeps a series of master files of the raw data. The AQB modified this system to handle new monitoring methods for particle sizing and other data and to produce more meaningful summary reports. Data is stored by pollution source location, frequency of sample collection, type of monitor, and pollutant type. The AQB data system relied on computer cards with a data format different from that of AQDHS and so a great deal of effort was required to modify the old data to fit the new system. A program to inventory the data presently on the master file also was prepared.

C. Meteorological Data System

Meteorological data can be categorized into two forms - upper air and surface. Surface data include such parameters as wind speed, wind direction, temperature, and precipitation. Upper air data include upper level wind data, inversion heights, and mixing heights. The AQDHS was designed by EPA to handle surface meteorological data. Some parameters such as solar radiation and stability required a significant amount of programming before they could be stored into the AQDHS. Appendix A describes in detail three programs prepared under MAPS to summarize the upper air data being collected in Montana

and to prepare the data for input to AQDHS. The documentation of the programs is written as a user's manual for AQB use. Examples of the program outputs are also given in the appendix.

III. AIR RESOURCE MODELS

The Clean Air Act Amendments (CAAA) of 1977 made significant additions to the federal air quality laws. Following the requirements of the CAAA, the EPA promulgated regulations enacting sections of this act. One important section of these regulations is the Prevention of Significant Deterioration of Air Quality (PSD). Under the PSD regulation, strict requirements were spelled out for the review of proposed new or modified air pollution sources in areas of the country where the air quality is superior to that required by the National Ambient Air Quality Standards. One of these requirements was the use of diffusion models approved by the Administrator of EPA. A list of recommended models was made available for specified pollutants and time periods.

Under MAPS, the AQB installed a series of these models, called the Users Network for Applied Modeling of Air Pollution (UNAMAP) Version III, on the Montana Department of Administration computer. These models included the Climatological Dispersion Model (CDM & CDMQC); Valley Model; Gaussian-Plume Multiple Source Air Quality Algorithm (RAM); Point, Area and Time Source Model (NEWPAL); HIWAY; PTMAX; PTDIS; PTMTP; and APRAC. Turner (1979) has summarized these models as follows: APRAC - Stanford Research Institute's urban carbon monoxide mode; computes hourly averages for any urban location. Requirements and technical details are documented in:

"User's Manual for the APRAC-1A Urban Diffusion Model Computer Program" (NTIS accession number PB 213-091).

Additional information is available on APRAC from:

"A Practical, Multipurpose Urban Diffusion Model for Carbon Monoxide" (NTIS accession number PB 196-003).

"Field Study for Initial Evaluation of an Urban Diffusion Model for Carbon Monoxide" (NTIS accession number PB 203-469)

"Evaluation of the APRAC-1A Urban Diffusion Model for Carbon Monoxide" (NTIS accession number PB 210-813)

Walter F. Dabberdt, F. L. Ludwig, and Warren B. Johnson Jr., "Validation and application of an urban diffusion model for vehicular pollutants," Atmos. Environ. 7:603 (1973).

W. B. Johnson, F. L. Ludwig, W. F. Dabberdt, and R. J. Allen, "An Urban Diffusion Simulation Model for Carbon Monoxide," J. Air Pollution Control Assoc. 23:490 (1973).

CDM The Climatological Dispersion Model determines long-term (seasonal) or annual) quasi-stable pollutant concentrations at any ground level receptor using average emission rates from point and area sources and a joint frequency distribution of wind direction, wind speed, and stability for the same period.

A. D. Busse and J. R. Zimmerman, "User's Guide for the Climatological Dispersion Model," U. S. Environmental Protection Agency, Research Triangle Park, NC, Environmental Monitoring Series, EPA-R4-73-024, 1973 (NTIS accession number PB 227-346).

HIWAY Computes the hourly concentration of nonreactive pollutants downwind of roadways. It is applicable for uniform wind conditions and level terrain. Although best suited for at-grade highways, it can also be applied to depressed highways (cut sections).

J. R. Zimmerman and R. S. Thompson, "User's Guide for HIWAY: A Highway Air Pollution Model," U. S. Environmental Protection Agency, Research Triangle Park, NC Environmental Monitoring Series, EPA-650/4-74-008, 1975 (NTIS accession number PB 239-944).

PTMAX Performs an analysis of the maximum short-term concentrations from a single point source as a function of stability and wind speed. The final plume height is used for each computation.

PTDIS Estimates short-term concentration directly downwind of a point source at distances specified by the user. The effect of limiting vertical dispersion by a mixing height can be included and gradual plume rise to the point of final rise is also considered. An option allows the calculation of isopleth half-widths for specific concentration at each downwind distance.

PTMIS Estimates for a number of arbitrarily located receptor points at or above ground-level, the concentration from a number of point sources. Plume rise is determined for each source. Downwind and crosswind distances are determined for each source-receptor pair. Concentrations at a receptor from various sources are assumed additive. Hourly meteorological data are used; both hourly concentrations and averages over any averaging time from one to 24 hours can be obtained.

D. B. Turner and A. D. Busse, "User's Guide to the Interactive Versions of Three Point Source Dispersion Programs: PTMAX, PTDIS, and PTMTP." Preliminary Draft, Meteorology Laboratory, U. S. Environmental Protection Agency, Research Triangle Park, NC 1973.

CDMQC This algorithm is the Climatological Dispersion Model (CDM) altered to provide implementation: of calibration, of individual point and area source contribution lists, and averaging time transformation. The basic

algorithms to calculate pollutant concentrations used in the CDM have not been modified, and results obtained using CDM may be reproduced using the CDMQC.

Kenneth L. Brubaker, Polly Brown, and Richard R. Cirillo, Addendum to User's Guide for Climatological Dispersion Model. Prepared by Argonne National Laboratory for the U. S. Environmental Protection Agency, Research Triangle Park, NC, EPA-450/3-77-015, 1977 (NTIS accession number PB 274-040).

CRSTER This algorithm estimates ground-level concentrations resulting from up to 19 elevated stack emissions for an entire year and prints out the highest and second-highest 1-hour, 3-hour and 24-hour concentrations and the annual mean concentrations at a set of 180 receptors (5 distances by 36 azimuths). The algorithm is based on a modified form of the steady-state Gaussian plume equation which uses empirical dispersion coefficients and includes adjustments for plume rise and limited mixing. Terrain adjustments are made as long as the surrounding terrain is lower than the lowest stack height. Pollutant concentrations for each averaging time are computed for discrete, non-overlapping time periods (no running averages are computed) using measured hourly values of wind speed and directions, and estimated hourly values of atmospheric stability and mixing height.

Monitoring and Data Analysis Division, User's Manual for Single-Source (CRSTER) Model. U. S. Environmental Protection Agency. Research Triangle Park, NC EPA-450/2-77-013, 1977 (NTIS accession number PB 271-360).

PAL Point, Area, Line source algorithm. This short-term Gaussian steady-state algorithm estimates concentrations of stable pollutants from point,

area, and line sources. Computations from area sources include effects of the edge of the source. Line source computations can include effects from a variable emission rate along the source. The algorithm is not intended for application to entire urban areas but for smaller scale analysis of such plants. Hourly concentrations are estimated and average concentrations from 1 hour to 24 hours can be obtained. William B. Petersen, User's Guide for PAL - A Gaussian-Plume Algorithm for Point, Area, and Line Sources. U. S. Environmental Protection Agency, Research Triangle Park, NC, Environmental Monitoring Series EPA-600/4-78-013, 1978 (NTIS accession number PB-281-306).

Valley This algorithm is a steady-state, univariate Gaussian plume dispersion algorithm designed for estimating 24-hour or annual concentrations resulting from emissions from up to 50 (total) point and area sources. Calculations of ground-level pollutant concentrations are made for each frequency in an array defined by six stabilities, 16 wind directions, and six wind speeds, for 112 program-designed receptor sites on a radial grid of variable scale. Empirical dispersion coefficients are used and the model includes adjustments for plume rise and limited mixing. Plume height is adjusted according to terrain elevations and stability classes. Edwar W. Burt, "Valley Model User's Guide," W. S. Environmental Protection Agency, Research Triangle Park, NC, EPA-450/2-77-018, 1977 (NTIS accession number PB 274-054).

RAM Gaussian-Plume Multiple Source Air Quality Algorithm. This short-term gaussian steady-state algorithm estimate concentrations of stable pollutants from urban point and area sources. Hourly meteorological data are used. Hourly concentrations and averages over any number of hours

can be estimated. Briggs plume rise is used. Pasquill-Gifford dispersion equations with dispersion parameters thought to be valid for urban areas are used. Concentrations from area sources are determined using the method of Hanna, that is, sources directly upwind are considered representative of area source emissions affecting the receptor. Special features include determination of receptor locations downwind of significant sources and determination of locations of uniformly spaced receptors to ensure good area coverage with a minimum number of receptors. D. Bruce Turner and Joan Hrenko Novak, "User's Guide for RAM," U. S. Environmental Protection Agency. Research Triangle Park, NC, EPA-600/8-78-016, November 1978.

Valley, CDM, and CDMQC models require meteorological data for calculating annual concentrations of pollutants in the form of a frequency distribution. The distribution, often called a star frequency because the data are grouped into sixteen sectors of the compass, require hourly data on stability, wind speed, and wind direction. The star frequency distribution can be obtained from the National Climatic Center in Asheville, NC, for various National Weather Service stations. However, for locally collected meteorlogical data, a frequency program had to be written. The program written is described in detail in Appendix B. Basically the program retrieves hourly data over any specified time period for wind speed, wind direction, and stability from AQDHS. These data then are tabulated into a frequency distribution. This distribution is then punched out by the computer for use in the various diffusion models. An Example listing of a star frequency distribution is also given in Appendix B.

CRSTER and RAM models from running annual concentrations require hourly

meteorological data. Unlike Valley and CDM, the CRSTER and RAM input data could not be a frequency distribution but required individual hours. A preprocessor program which took input data and grouped it into a correct format for entry into the models was supplied with the models. However, the preprocessor program was designed for reading and dealing with National Weather Service data. To allow the use of local meteorological data, a customized preprocessor program had to be written to use data taken from the AQDHS data system (see Appendix B for detailed description).

As an example of the ARMS, a model was used to simulate hypothetical industrial development around the Fort Peck Indian Reservation. A series of possible air pollution sources were modeled in an effort to determine what the expected concentrations of pollutants would be on the reservation. The model used was Valley. Since the air pollution sources modeled were hyopthetical, the emission data regarding these sources were not on the EIS/P&R system. However, data on the existing air quality were retrieved from AQDHS (an example printout is given in Appendix C). The present air quality levels were well within the ambient air quality standards. Using the star frequency program from Appendix B, a frequency distribution of wind speed, wind direction, and stability data was prepared from data collected just north of the reservation at the Scobey Border Station (Gelhaus, 1979). The modeling was performed using the star frequency, the hypothetical plants, and the present air quality.

A listing of the star frequency and the computer model printout for one of these sources is given in Appendix C. The modeling showed that the hypothetical concentrations of air pollutants on the reservations would not exceed the ambient air quality standards.

IV. SUMMARY

A diffusion modeling system is now available for use by the AQB in evaluating new plants or plants requesting modifications. The modeling system consists of the diffusion models endorsed by the Administrator of EPA. A great deal of effort was expended in developing a system to utilize the local meteorolgoical data collected by the AQB and other groups. Use of these data greatly improved the accuracy of the models. Existing data systems also were used for the handling of emissions and air quality data. User's manuals for AQB personnel are now available to enhance operation of the models and make it easier to obtain the input data. It will still take some time following execution of these models to determine the significance of the model results with respect to each proposed new plant. However, the time saved with the new system can be spent on the interpretation of the results.

APPENDIX A

METEOROLOGICAL DATA SUMMARY PROGRAMS

ACOUSTIC RADAR COMPUTER ANALYSIS USER MANUAL

Prepared by: Thomas G. Stewart, P.E.
Consultant

For: Department of Health and
Environmental Sciences
Air Quality Bureau

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CHAPTER 1

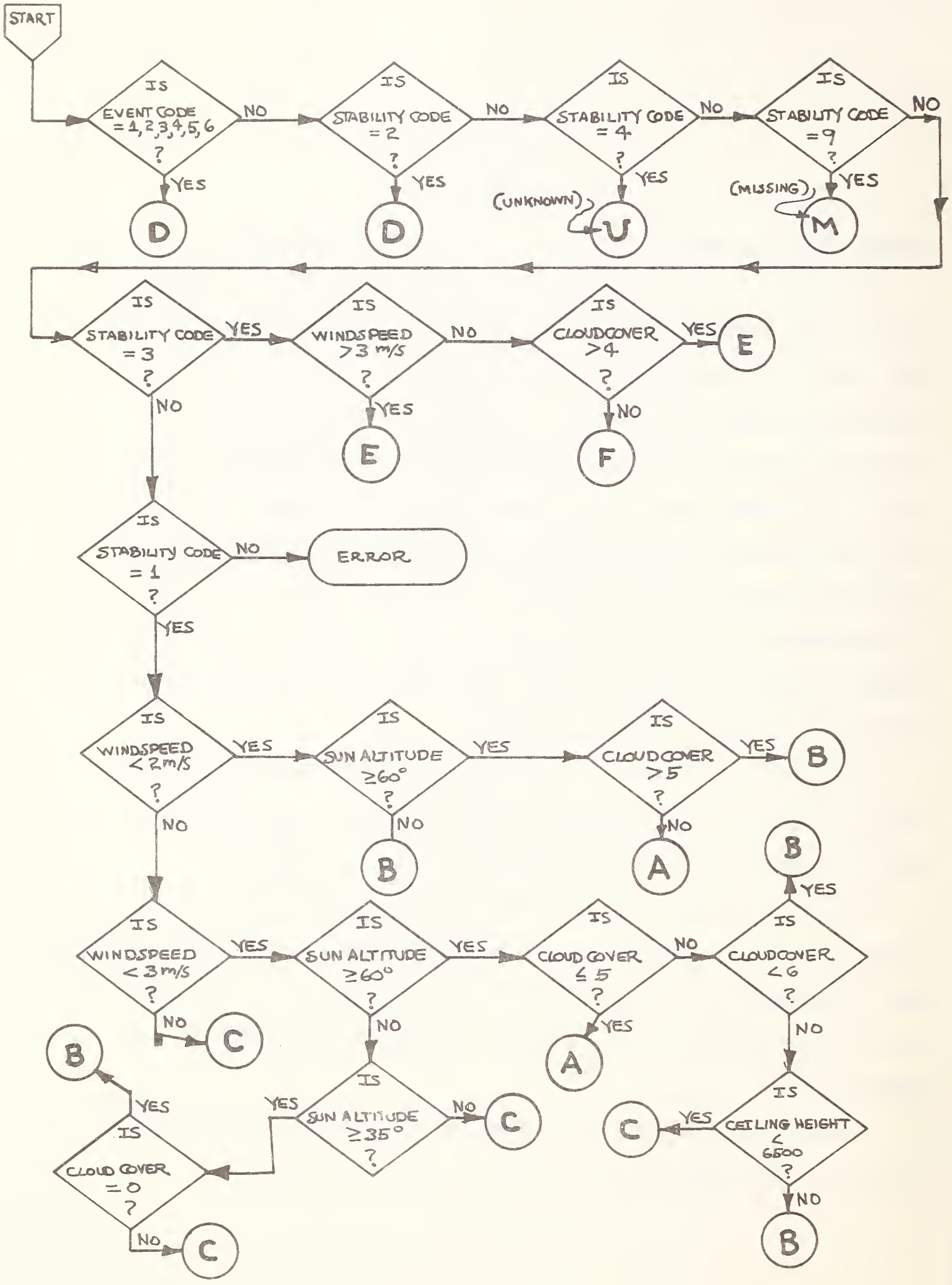
General Method of Analysis

The monostatic acoustic sounder manufactured by AeroEnvironment, Inc. consists of a transmit/receive dish antenna approximately four feet in diameter and a recording/display unit which produces a permanent chart record. Approximately every 22 seconds the antenna emits a 1600 Hz sound pulse. The pulse is directed vertically upward and is reflected downward to the receiver, if stable layers are present, by small-scale turbulence and temperature discontinuities associated with inversions. The echoes received are recorded electrically on heat-sensitive chart paper. The chart produced is interpreted by the operator, who obtains from it a stability estimate (stable, unstable, or neutral) of the lowest 100 meters, and the height, thickness, and type of inversions present.

This data is recorded on a predesigned coding form according to rules given on a special instruction sheet which accompanies the coding form. An example of the coding form and Instruction sheet are in Appendix A-1.

The program produces from this data monthly summary reports of the First (lowest) and second (second lowest if multiple inversions) inversion information and a frequency of occurrence summary for these inversions. This is followed by a two hour stability analysis report. Examples of these reports are in Appendix A-1.

The most involved part of the computer analysis is in determining the stability classifications 'A' through 'F' shown in the report.


START
IS EVENT CODE = 1,2,3,4,5,6 ?
NO
YES
D
IS STABILITY CODE = 2 ?
NO
YES
D
IS STABILITY CODE = 4 ?
NO
YES
(UNKNOWN)
U
IS STABILITY CODE = 9 ?
NO
YES
(MISSING)
M
IS STABILITY CODE = 3 ?
YES
NO
IS WINDSPEED > 3 m/s ?
NO
YES
E
IS CLOUDCOVER > 4 ?
YES
E
NO
F
IS STABILITY CODE = 1 ?
NO
ERROR
YES
IS WINDSPEED < 2 m/s ?
YES
NO
IS SUN ALTITUDE ≥ 60° ?
YES
NO
B
IS CLOUDCOVER > 5 ?
YES
B
NO
A
IS WINDSPEED < 3 m/s ?
YES
NO
C
IS SUN ALTITUDE ≥ 60° ?
YES
NO
A
IS CLOUD COVER ≤ 5 ?
NO
YES
A
B
YES
IS CLOUDCOVER < 6 ?
NO
IS CEILING HEIGHT < 6500 ?
YES
C
NO
B
B
YES
IS CLOUD COVER = 0 ?
NO
C
YES
IS SUN ALTITUDE ≥ 35° ?
NO
C

The two hour stability and event coding information recorded in the field is further refined using additional meteorological information in the program. The stability classification method used in the analysis is suggested by Turner and summarized in "The Workbook of Atmospheric Dispersion Estimates" published by the Environmental Protection Agency, January 1974. The six stability classifications are A, B, C, D, E and F where A is the most unstable and F the most stable atmospheric condition. The classification type is arrived at by taking into account the wind speed, time of day, solar altitude and cloud conditions.

The program input for this analysis includes the two-hour stability and event code from the acoustic radar coding form, National Weather Service (NWS) data from the station nearest to the site, and wind data recorded at the site, if available. If the wind data for the site are not available, the NWS wind data is used in its place.

The following is a schematic of the logic flow used in the program to determine the A through F classification for each two hour period.

The cloud cover and ceiling heights information are taken from the National Weather Service data.

The program generates a table of the sun's approximate altitude above the horizon for the analysis using the following equations:

1. HH = (XLONG - 105.0) 4/60 + 12.00
2. DD = 23.45SIN(360(284+ N)/365)/57.29578
3. HA = ABS(HH-x)15.0/57.29578
4. AA = SIN(DD)·SIN(XLAT) + COS(DD)·COS(XLAT)·COS(HA)
5. ALT = ARCSINE (AA) * 57.29578

Where: XLONG = Longitude at site (input) radians

XLAT = Latitude at site (input) radians

X = Time (MST)

N = Day of the year

HH = Solar time (hours)

DD = estimate of sun's declination

HA = Hour angle (radians)

AA = Sine of the altitude

ALT = altitude (degrees)

Note that in equation 1 no correction is made for the equation of time. Also equation 2 is an emperical relation to estimate the sun's declination. The altitudes computed using the above equations were found to be within $\pm 1^{o}$ of the true altitudes in the range of altitudes critical to the stability classification routine.[1]

---

[1]The emperical equation 2 was taken from "Solar Energy and Thermal Processes" by Beckman & Duffie, John Wiley and Sons, 1974, page 15.

The program in addition outputs the inversion and stability data to a tape file which is used as input to the AQDHS master data file. Details of this procedure are covered in Chapter 4.

Chapter 2

INPUT DATA PREPARATION

A. Card Input

Acoustic Radar Cards

Appendix A-1 has an example coding form along with an instruction sheet which make the coding procedure self-explanatory. It should be noted that all values coded are either numeric or the entry is left blank. This data is keypunched on cards for input to program.

Title Card

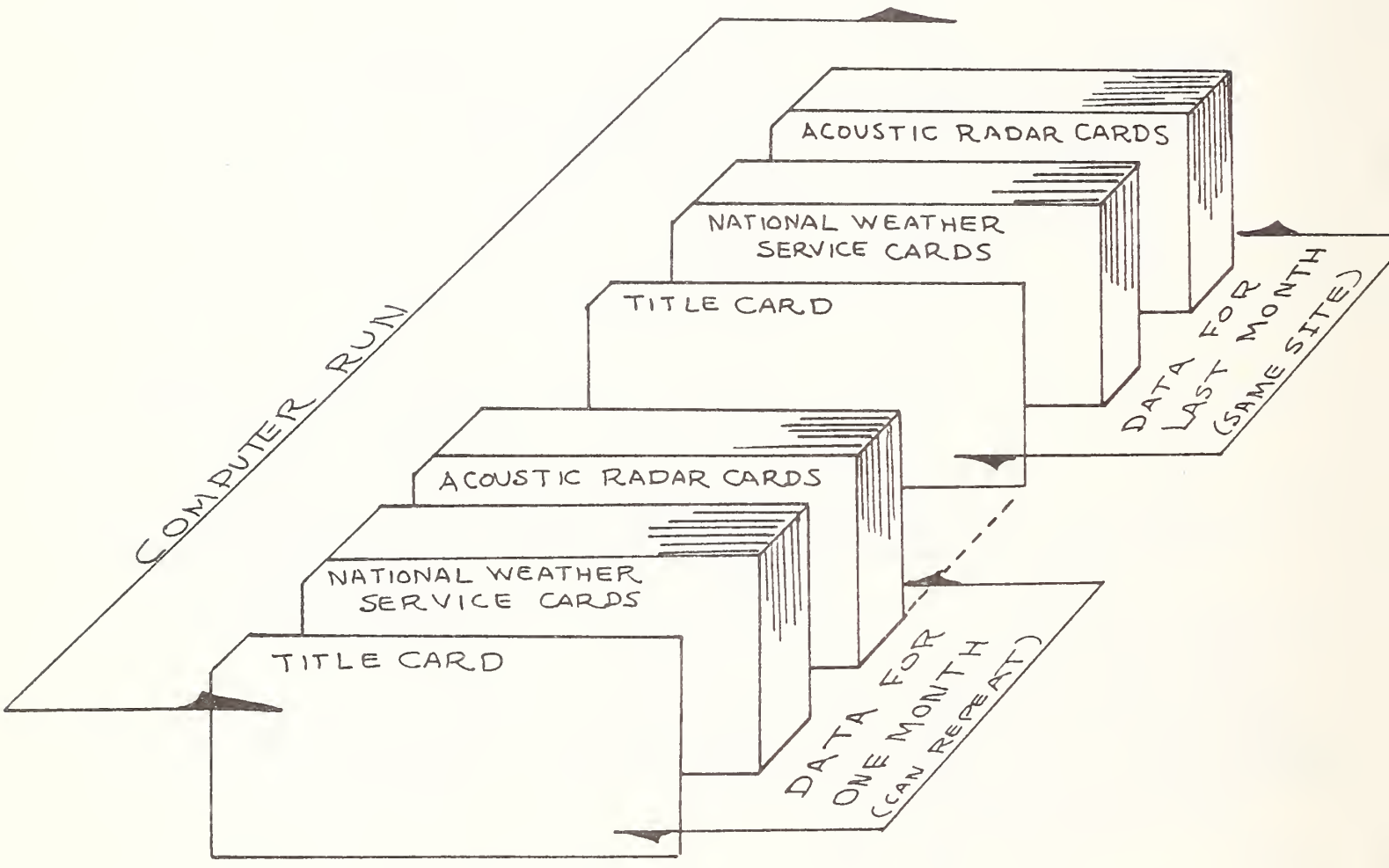
COL	Field	Type	Description	Remarks
1-40	x . . x	Non-numeric	Site Description	Used for title on the output reports
41-50	±9999999^99	numeric	Latitude at site (Decimal degrees)	For latitude and longitude entries the plus sign is optional. Values can optionally be coded with the decimal point anywhere within the 10 column field. Leading zeroes may be left blank.
51-60	±9999999^99	numeric	Longitude at site (decimal degrees)	
61-26	99^	numeric	Month	
63-64	99^	numeric	Year	
65	9^	numeric	Windspeed Data Flat 1 = site wind 2 = NWS wind	If column 65 is coded "1" then the program uses wind data from the site which is retrieved from AQDHS. If coded "2" then NWS wind data is used.
66-80	*Not used*			

National Weather Station Card Deck 144

This data is available from the National Climatic Center along with a reference manual which documents the data punched on these cards. Only the information needed from these cards for stability analysis are described below:

COL	Field	Type	Description	Remarks
1-5	99999$_{\wedge}$	numeric	Station Number	
6-7	99$_{\wedge}$	numeric	year	
8-9	99$_{\wedge}$	numeric	month	
10-11	99$_{\wedge}$	numeric	day	
12-13	99$_{\wedge}$	numeric	Hour	8 hours are available at 00, 03, 06, 09, 12, 15, 18 and 21 hours
14-16	xxx	non-numeric or numeric	Ceiling Height Range 000 to 999 feet.	X over punches equivalent to minus signs are used in this field if the ceiling height is "unlimited."
17-40		*not used*		
41-42	xx	numeric or non-numeric	wind speed in knots	X over punches indicates 100 or more knots
43-55		*Not used*		
56	x	numeric or non-numeric	Total Sky Cover rated in tenths 0-9	X over punch indicates 10

The following shows the Input Arrangement for the CARD INPUT.



A computer run can be made up of 1 to 12 months of data for one site location.

B. Tape Input

Wind data for the site (if available) is stored on the AQDHS masterfile. This data is retrieved from the masterfile and written to magnetic tape which becomes input to the computer run. The user must code select cards to retrieve the wind data for the desired site and dates. Details of this can be found in the Montana AQDHS procedure manual. An example set of select statements are shown below:

```
$$SELECT
AREA-CODE          = '0340'          AND
SITE               = '001'           AND
YEAR               = '78'            AND
PARAMETER-CODE     = '61101'
$$END
```

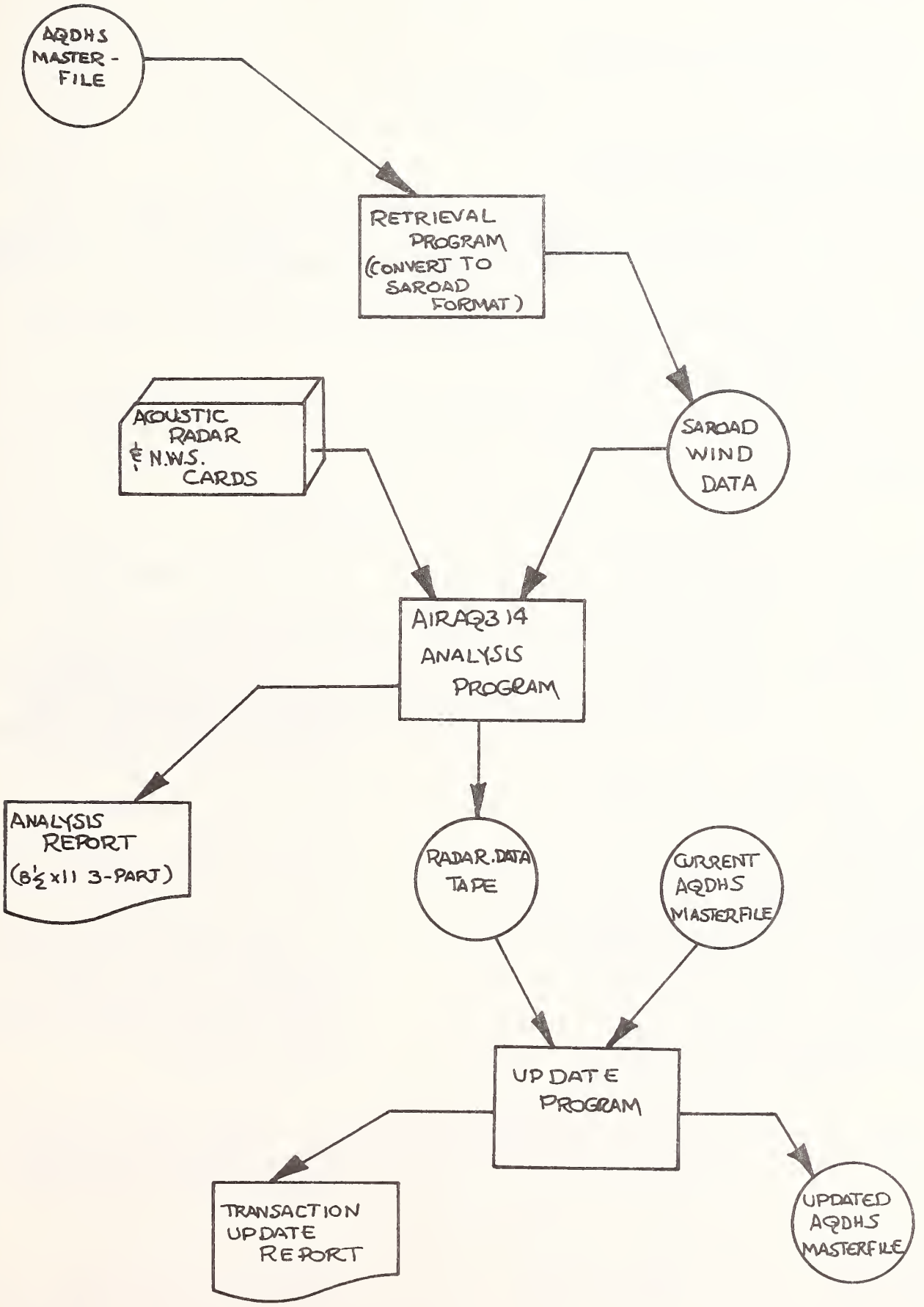
This example will cause an input tape to be created containing all the hourly wind data available for the year 1978 for area '0340' and site location 1. The format of the tape data is the SAROAD format and is identical to that shown on the SAROAD hourly data form (see Appendix A-1).

Chapter 3

Data Flow Through System

The acoustic radar computer run is a cataloged procedure named P05607M. The job control and instructions to use the procedure can be found in the Montana AQDHS Procedure Manual. The main program in the procedure is named AIRAQ314 which performs the analysis and produces the output report as shown in the example in Appendix A-1. In addition the program produces an output magtape containing the inversion and stability data in the format required for input to the AQDHS masterfile. Details of the parameter codes and record formats used to generate the tape are given in Chapter 4. The data set name for this tape is "RADAR.DATA." Procedure P05607D is used to update AQDHS with this tape. The output reports should be examined carefully for possible errors before updating the masterfile with this tape.

A schematic of the data flow follows:


AQDHS MASTER - FILE
RETRIEVAL PROGRAM (CONVERT TO SAROAD FORMAT)
ACOUSTIC RADAR & N.W.S. CARDS
SAROAD WIND DATA
AIRAQ3 14 ANALYSIS PROGRAM
ANALYSIS REPORT (8½x11 3-PART)
RADAR.DATA TAPE
CURRENT AQDHS MASTERFILE
UPDATE PROGRAM
TRANSACTION UPDATE REPORT
UPDATED AQDHS MASTERFILE

Chapter 4

Parameter Codes for AQDHS Input

All data values except the frequency of occurrence tables shown on the example report in Appendix A-1 are written to the magtape created by program AIRAQ314. This file is formated to satisfy the requirements of the input transaction Format 1 for AQDHS.

The following is a description of the codes and the type of values generated.

		REMARKS
FORM CODE	"1"	Transaction form code
State Code	"27"	Montana State
AREA CODE	9999	4 digit area code taken from acoustic radar input data. 3 digit site code taken from acoustic radar input data.
Agency Code	"F"	State Agency Montana
Project Code	99	2 digit project number taken from acoustic radar input data
Time Code	"5" or "2"	"5" represents 6 hour interval data used for the inversion data and "2" represents a 2 hour interval used for the stability data.
Year	99	
Month	99	Date values are taken from the acoustic radar input data.
Day	99	
START HOUR	"00" or "16"	beginning military hour fixed at the start hour "16" is explained below for parameter code 61501

METHOD CODE	"11"	Fixed by program and constant for all records generated.
Decimal Position	"0"	Fixed by program and constant for all records generated.
STATUS FLAG	"S"	Constant fixed by program.
Action Code	"2"	Constant fixed by program.

PARAMETER CODE	UNITS CODE	No. of 4 digit Readings	REMARKS
61401	57	4	First Inversion Base
61402	57	4	First Inversion Top
61403	59	4	First Inversion Type
61411	57	4	Second Inversion Base
61412	57	4	Second Inversion Top
61413	59	4	First Inversion Type

NOTE: First readings values are for hours 0-600 MST. Second reading values are for hours 601-1200 MST. Third reading values are for hours 1201-1800 MST. Fourth reading values are for hours 1801-2400 MST. A value of "8888" is used to indicate no inversion.

61501	59	12	Stability classification - where the reading is: "1" for A "2" for B, "3" for C, "4" for D, "5" for E, "6" for F and "9" for unknown. There is 1 reading for each two-hour interval. Two records are generated with first record containing 8 readings with a start hour of "00" and the second containing 4 readings with a start hour of "16".

NOTE: Where a data value is missing the appropriate reading value is left blank. The AQDHS update procedure fills these fields with 9999's.

APPENDIX A-1

Acoustic Radar Summary

Site, Area, A, Pro. codes will be assigned by the Air Quality Bureau.

All times are MST.

All heights are in meters.

Stability and Event Codes

Hour 2 refers to 0000 to 0159 MST

Hour 4 refers to 0200 to 0359 MST, etc.

S refers to the stability code of lower 100m

1 = unstable - spiked, thermals

2 = neutral - no echo, high winds, or transition

3 = stable - layers, inversion etc.

4 = unknown

9 = missing

E refers to the event code

blank = no event occurring

1 = ppn - light intensity

2 = ppn - moderate intensity

3 = ppn - heavy intensity

4 = ppn - intensity unknown

5 = frontal passage

6 = inversion breakup

7 = inversion formation

Inversion Height, Base and Type code

First or Second inversion-code data only if present

H refers to height code

1 - 100m maximum height (dominant portion of echo, not spikes)

2 - 200m etc.

blank - missing or unknown

B refers to base code

0 = surface based inversion (30)

1 = 100m, etc.

T refers to the type of inversion

1 = frontal

2 = subsidence

3 = radiation (spiked echo, indicating small scale turbulence within)

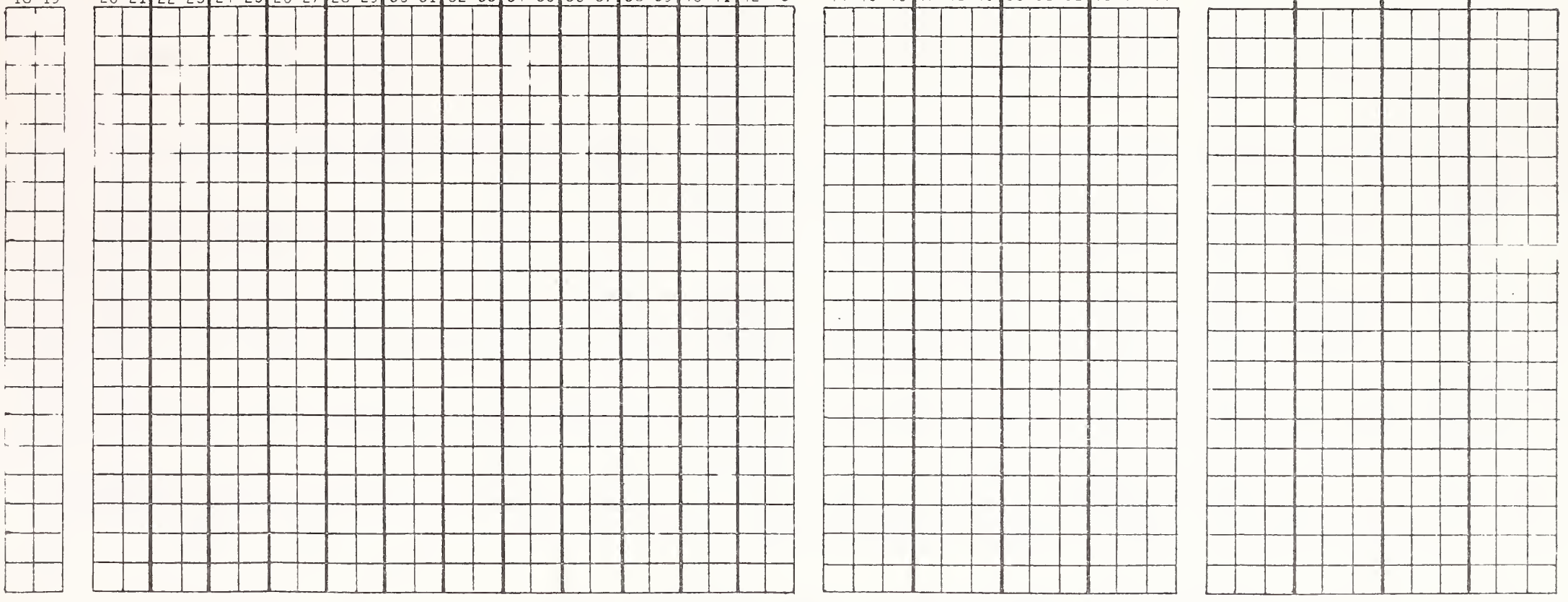
4 = radiation (laminar echo)

9 = unknown

For stability codes, code the dominant stability of the two hour period, also remember stability should quantify ability of atmosphere to disperse pollution. Inversions lasting past midnight can be tracked by inversion type. Never code two elevated inversions. Always pick the most dominant or lower inversion. For multiple layers, inversion height is the top of those layers. Inversion height (6 hour) is average height of that period.

All Times MST ACOUSTIC RADAR COMPUTER SUMMARY All Heights in Meters

STATE	AREA	SITE	PRO	YEAR	MONTH
1 2 3	4 5 6 7	8 9 10 11	12 13	14 15	16 17



LESS THAN 24-HOUR SAMPLING INTERVAL

AIR QUALITY BUREAU

[1] (1) Agency

City Name

Site Address

Parameter observed

Method

Time interval of obs.

Units of obs.

State (2 3) Area (4 5 6 7) Site (8 9 10)

Agency (11) | Project (12 13) | Time (14) | Year (15 16) | Month (17 18)

Parameter code (23 24 25 26 27) | Method (28 29) | Units (30 31) | DP (32)

Project

Day	St	Hr	Rdg 1	Rdg 2	Rdg 3	Rdg 4	Rdg 5	Rdg 6	Rdg 7	Rdg 8	Rdg 9	Rdg 10	Rdg 11	Rdg 12
(19 20)	(21)	(22)	(33 34 35 36)	(37 38 39 40)	(41 42 43 44)	(45 46 47 48)	(49 50 51 52)	(53 54 55 56)	(57 58 59 60)	(61 62 63 64)	(65 66 67 68)	(69 70 71 72)	(73 74 75 76)	(77 78 79 80)
01	0	0												
01	1	2												
02	0	0												
02	1	2												
03	0	0												
03	1	2												
04	0	0												
04	1	2												
05	0	0												
05	1	2												
06	0	0												
06	1	2												
07	0	0												
07	1	2												
08	0	0												
08	1	2												
09	0	0												
09	1	2												
10	0	0												
10	1	2												
11	0	0												
11	1	2												
12	0	0												
12	1	2												
13	0	0												
13	1	2												
14	0	0												
14	1	2												
15	0	0												
15	1	2												
16	0	0												

SAROAD Hourly Data Form.

ACOUSTIC RADAR ANALYSIS

FLATHEAD ENVIRONMENTAL STUDY — MONTH OF JANUARY 1979

FIRST INVERSION

DAY	0000-0600 MST BASE (100M)	TOP (100M)	TYPE *	0601-1200 MST BASE (100M)	TOP (100M)	TYPE *	1201-1800 MST BASE (100M)	TOP (100M)	TYPE *	1801-2400 MST BASE (100M)	TOP (100M)	TYPE *
1	0	5	4	0	4	4	0	2	4	0	2	4
2	0	2	4	0	2	4	N	N	N	0	3	4
3	0	3	4	0	4	4	2	4	4	0	3	4
4	0	2	3	0	4	4	2	3	4	0	?	4
5	0	4	4	0	4	4	0	2	4	0	4	4
6	0	3	4	0	3	4	0	2	4	0	2	4
7	0	2	4	0	5	4	0	4	4	0	2	4
8	0	4	4	0	5	4	1	5	4	0	1	4
9	0	2	4	0	5	4	2	5	4	4	5	4
10	2	4	4	1	4	4	0	3	4	N	N	N
11	N	N	N	N	N	N	N	N	N	0	5	4
12	0	3	4	2	3	3	1	2	3	0	1	4
13	N	N	N	N	N	N	N	N	N	N	N	N
14	N	N	N	N	N	N	0	4	4	0	3	4
15	N	N	N	N	N	N	0	2	4	0	3	4
16	0	4	4	0	1	4	3	4	4	0	4	4
17	0	4	4	0	4	4	0	4	4	0	3	4
18	0	3	4	0	4	4	0	4	4	0	4	4
19	0	4	4	0	4	4	1	4	4	2	4	4
20	1	4	4	1	4	4	2	4	4	0	3	4
21	0	2	4	0	1	4	N	N	N	0	1	3
22	0	2	3	0	4	4	0	3	4	0	5	4
23	0	2	4	0	3	4	0	1	4	0	1	4
24	0	4	4	0	3	4	0	3	4	0	3	4
25	0	3	4	0	3	4	N	N	N	0	3	4
26	0	3	4	0	3	4	N	N	N	N	N	N
27	N	N	N	N	N	N	N	N	N	0	2	4
28	0	2	4	0	2	4	1	3	4	N	N	N
29	0	2	4	0	2	4	3	4	4	3	4	4
30	0	1	4	0	1	4	3	5	4	0	1	4
31	0	2	4	0	5	4	0	5	4	0	3	4

SECOND INVERSION

DAY	0000-0600 MST BASE (100M)	TOP (100M)	TYPE *	0601-1200 MST BASE (100M)	TOP (100M)	TYPE *	1201-1800 MST BASE (100M)	TOP (100M)	TYPE *	1801-2400 MST BASE (100M)	TOP (100M)	TYPE *
1	N	N	N	N	N	N	N	N	N	N	N	N
2	N	N	N	N	N	N	N	N	N	N	N	N
3	N	N	N	N	N	N	N	N	N	N	N	N
4	N	N	N	N	N	N	N	N	N	N	N	N
5	N	N	N	N	N	N	N	N	N	N	N	N
6	N	N	N	N	N	N	N	N	N	4	5	4
7	4	5	4	N	N	N	N	N	N	4	5	4
8	N	N	N	N	N	N	N	N	N	3	5	4
9	N	5	4	N	N	N	N	N	N	N	N	N
10	N	N	N	N	N	N	N	N	N	N	N	N
11	N	N	N	N	N	N	N	N	N	N	N	N
12	N	N	N	N	N	N	4	5	4	4	5	4
13	N	N	N	N	N	N	N	N	N	N	N	N
14	N	N	N	N	N	N	N	N	N	N	N	N
15	N	N	N	N	N	N	N	N	N	N	N	N
16	N	N	N	2	4	N	N	N	N	N	N	N
17	N	N	N	N	N	N	N	N	N	N	N	N
18	N	N	N	N	N	N	N	N	N	N	N	N
19	N	N	N	N	N	N	N	N	N	5	6	4
20	N	N	N	N	N	N	5	6	4	4	5	4
21	3	4	4	N	N	N	N	N	N	N	N	N
22	N	N	N	N	N	N	N	N	N	N	N	N
23	N	N	N	N	N	N	2	4	4	2	4	4
24	N	N	N	4	5	4	N	N	N	N	N	N
25	N	N	N	N	N	N	N	N	N	N	N	N
26	N	N	N	N	N	N	N	N	N	N	N	N
27	N	N	N	N	N	N	N	N	N	N	N	N
28	3	4	4	3	4	4	N	N	N	N	N	N
29	5	6	4	5	6	4	N	N	N	N	N	N
30	4	5	4	5	6	4	N	N	N	N	N	N
31	3	4	4	N	N	N	N	N	N	N	N	N

NOTE: FOR TYPE 1=FRONTAL, 2=SUBSIDENCE, 3=RADIATION (SPIKED ECHO)
4=RADIATION (LAMINAR ECHO) 9=UNKNOWN
N=NO LEVEL TO ... M=MISSING DATA OR UNKNOWN

ACOUSTIC RADAR ANALYSIS

FLATHEAD ENVIRONMENTAL STUDY MONTH OF JANUARY 1979

******* FIRST INVERSION FREQUENCY OF OCCURENCE TABLE *******

THICKNESS (METERS)	SFC	INVERSION BASE HEIGHT (IN METERS) 100	200	300	400	500	600	700	800	900	TOTAL
---TIME 0- 600 MST											
001-100	1	0	0	0	0	0	0	0	0	0	1
101-300	16	1	1	0	0	0	0	0	0	0	18
301-500	7	0	0	0	0	0	0	0	0	0	7
501-900	0	0	0	0	0	0	0	0	0	0	0
NO INVERSION											5
TOTAL	24	1	1	0	0	0	0	0	0	0	31
---TIME 601-1200 MST											
001-100	3	0	1	0	0	0	0	0	0	0	4
101-300	8	2	0	0	0	0	0	0	0	0	10
301-500	12	0	0	0	0	0	0	0	0	0	12
501-900	0	0	0	0	0	0	0	0	0	0	0
NO INVERSION											5
TOTAL	23	2	1	0	0	0	0	0	0	0	31
---TIME 1201-1800 MST											
001-100	1	1	1	2	0	0	0	0	0	0	5
101-300	7	2	3	1	0	0	0	0	0	0	13
301-500	5	1	0	0	0	0	0	0	0	0	6
501-900	0	0	0	0	0	0	0	0	0	0	0
NO INVERSION											7
TOTAL	13	4	4	3	0	0	0	0	0	0	31
---TIME 1801-2400 MST											
001-100	5	0	0	1	1	0	0	0	0	0	7
101-300	14	0	1	0	0	0	0	0	0	0	15
301-500	5	0	0	0	0	0	0	0	0	0	5
501-900	0	0	0	0	0	0	0	0	0	0	0
NO INVERSION											4
TOTAL	24	0	1	1	1	0	0	0	0	0	31
---------- FREQUENCY SUMMARY FOR FIRST INVERSION ----------											
001-100	10	1	2	3	1	0	0	0	0	0	17
101-300	45	5	5	1	0	0	0	0	0	0	56
301-500	29	1	0	0	0	0	0	0	0	0	30
501-900	0	0	0	0	0	0	0	0	0	0	0
NO INVERSION											21
TOTAL	84	7	7	4	1	0	0	0	0	0	124

ACOUSTIC RADAR ANALYSIS

LATHEAD ENVIRONMENTAL STUDY MONTH OF JANUARY 1979

******* SECOND INVERSION FREQUENCY OF OCCURENCE TABLE ******

THICKNESS (METERS)	INVERSION BASE HEIGHT (IN METERS) SFC	100	200	300	400	500	600	700	800	900	TOTAL
--TIME 0- 600 MST											
001-100	0	0	0	3	3	1	0	0	0	0	7
101-300	0	0	0	0	0	0	0	0	0	0	0
301-500	0	0	0	0	0	0	0	0	0	0	0
501-900	0	0	0	0	0	0	0	0	0	0	0
0 INVERSION											24
TOTAL	0	0	0	3	3	1	0	0	0	0	31
--TIME 601-1200 MST											
001-100	0	0	0	1	1	2	0	0	0	0	4
101-300	0	0	1	0	0	0	0	0	0	0	1
301-500	0	0	0	0	0	0	0	0	0	0	0
501-900	0	0	0	0	0	0	0	0	0	0	0
0 INVERSION											26
TOTAL	0	0	1	1	1	2	0	0	0	0	31
--TIME 1201-1800 MST											
001-100	0	0	0	0	1	1	0	0	0	0	2
101-300	0	0	1	0	0	0	0	0	0	0	1
301-500	0	0	0	0	0	0	0	0	0	0	0
501-900	0	0	0	0	0	0	0	0	0	0	0
0 INVERSION											28
TOTAL	0	0	1	0	1	1	0	0	0	0	31
--TIME 1801-2400 MST											
001-100	0	0	0	0	4	1	0	0	0	0	5
101-300	0	0	1	1	0	0	0	0	0	0	2
301-500	0	0	0	0	0	0	0	0	0	0	0
501-900	0	0	0	0	0	0	0	0	0	0	0
0 INVERSION											24
TOTAL	0	0	1	1	4	1	0	0	0	0	31
---------- FREQUENCY SUMMARY FOR SECOND INVERSION ----------											
001-100	0	0	0	4	9	5	0	0	0	0	18
101-300	0	0	3	1	0	0	0	0	0	0	4
301-500	0	0	0	0	0	0	0	0	0	0	0
501-900	0	0	0	0	0	0	0	0	0	0	0
0 INVERSION											102
TOTAL	0	0	3	5	9	5	0	0	0	0	124

ACOUSTIC RADAR ANALYSIS

FLATHEAD ENVIRONMENTAL STUDY — MONTH OF JANUARY 1979

********** TWO HOUR STABILITY ANALYSIS **********

	HOUR											
DAY	02	04	06	08	10	12	14	16	18	20	22	24
1	F	F	F	F	E	E	E	E	E	E	E	E
2	E	D	D	D	D	D	D	C	C	F	F	F
3	F	F	F	E	E	D	D	D	D	E	E	E
4	E	E	E	F	F	D	D	D	F	F	F	F
5	E	F	F	E	E	E	F	D	D	F	F	F
6	F	F	F	F	F	F	F	C	D	E	E	E
7	E	E	E	E	F	F	F	F	F	F	F	F
8	F	D	D	D	D	D	D	D	F	F	F	F
9	F	E	E	E	D	D	D	B	C	C	C	D
10	D	D	D	C	D	E	D	D	C	C	C	D
11	D	D	D	D	D	D	M	M	E	C	C	D
12	D	D	D	D	D	D	D	C	E	C	C	D
13	D	D	D	D	D	D	D	M	M	M	M	M
14	M	M	M	M	E	E	E	E	E	C	C	D
15	D	D	D	D	D	D	E	D	E	F	C	C
16	D	D	D	D	D	D	D	C	C	E	C	D
17	D	D	D	D	D	D	F	F	F	F	F	F
18	E	E	D	D	D	D	D	C	F	E	E	E
19	D	D	D	D	D	D	D	D	D	C	C	D
20	C	D	D	D	D	D	D	D	C	C	E	D
21	D	D	D	D	D	D	D	D	D	E	E	E
22	E	F	F	F	E	E	E	E	C	C	C	E
23	E	E	E	E	E	D	D	C	E	E	E	E
24	D	D	D	D	D	D	F	E	E	E	E	E
25	E	F	F	F	D	F	D	C	D	E	E	E
26	E	E	E	E	E	D	D	M	M	M	M	M
27	D	D	D	D	D	D	M	D	C	E	C	F
28	E	E	E	E	E	E	D	C	D	C	D	E
29	D	D	D	D	D	D	D	D	C	C	C	D
30	C	E	D	E	E	D	D	C	C	C	E	E
31	E	E	E	E	E	E	E	E	E	E	E	E

PERCENT FREQUENCY OF OCCURENCE FOR EACH CATEGORY

A= 0.0 % B= 0.3 % C= 0.0 % D=50.8 % E=28.2 % F=16.1 %

U= 0.0 % M= 4.6 %

NOTE: U=UNKNOWN M=MISSING DATA
CLOUD COVER CONDITIONS USED FROM NWS STATION AT KALISPELL
WIND DATA USED FROM NWS STATION AT KALISPELL

UPPER AIR FREQUENCY SUMMARY

USER MANUAL

Prepared by: Thomas G. Stewart P.E.
Consultant

For: Department of Health and Environmental Sciences
Air Quality Bureau

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CHAPTER 3: Parameter Codes for AQDHS	45
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CHAPTER 1

Introduction

The upper air frequency summary procedure calculates and writes monthly frequency reports for upper air data stored on the Montana AQDHS master data file. This data was previously generated and stored by the upper air pilot balloon computer system. Appendix A-2 contains an example of the frequency reports.

The program produces 20 windrose frequency tables for 10 different elevation levels and for both morning and afternoon data. Further, the program produces frequency tables of invesrion base heights for a given inversion along with corresponding tables of inversion base height inversion types. Finally the program produces frequency tables for given mixing heights along with an average windspeed through the mixed layer and an average lapse rate below the first inversion.

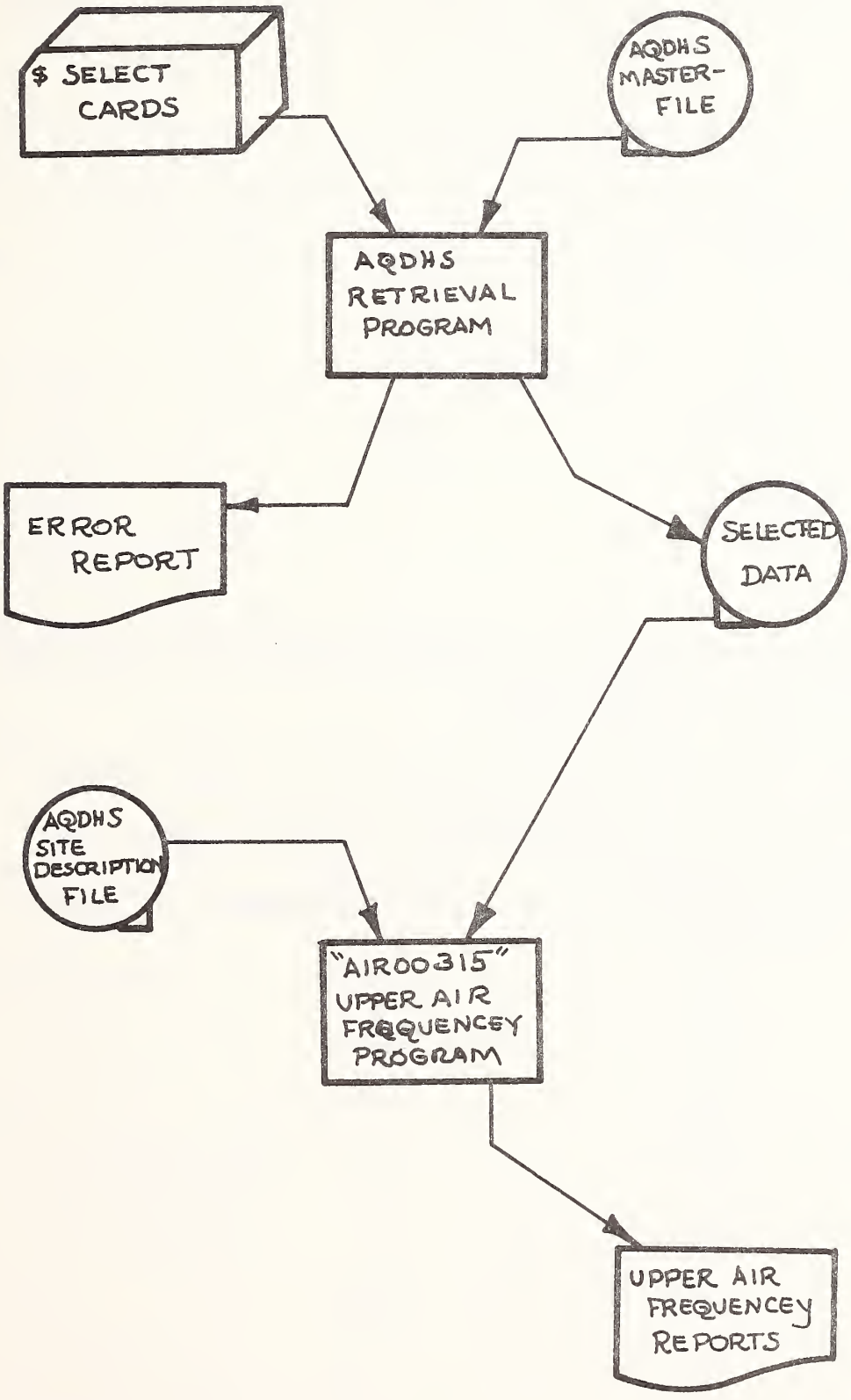
All input required by the program is retrieved from AQDHS. A given computer run allows up to a full year data for one given site location. The reports are printed on 3 part 8½ x 11 white paper. Details for preparing parameters for retrieving the desired upper air data is explained in Chapter 2. A schematic showing the data flow through the computer system is also presented in Chapter 2. Parameter codes pertaining to the computer run are explained in Chatper 3.

The main program in the procedure is program "AIR00315" written in Cobol.

The procedure itself is cataloged under the name P05607N. The job control

language for the procedure is documented in the Montana Air Quality Bureau AQDHS procedure manual.

The following is a schematic showing the data flow through procedure P05607N:



The only card input preparation required by the user is for the select cards. The rules for preparing select cards for retrieval of data from AQDHS is covered in the Montana AQDHS user manual. An example set is shown below.

```
$SELECT
AREA  CODE            = "0480"              AND
SITE CODE             = "001"               AND
YEAR                  = "79"                AND
PARAMETER-CODE        = "61309"             AND
PARAMETER-CODE        = "61400"
$ END
```

This particular set will retrieve all the necessary data for a full year 1979 for area "0480" (Scobey) and site '001'.

There are currently 10 site locations now available on AQDHS for which data can be retrieved and run through the frequency summary program. All coding necessary to select data from these sites are documented in Chapter 3.

Chapter 3

The following are the descriptions of the code number used for the upper air data stored on the Montana Air Quality Bureau AQDHS masterfile which are needed to retrieve the desired data for the upper air frequency report.

Description	AQDHS CODE NUMBER
ACTION-CODE	2
FORM -CODE	1
STATE-CODE	27
AGENCY-CODE	F
YEAR	Two digits
MONTH	Two digits
DAY	Two digits

Site Locations	AREA CODE NO.	AQDHS SITE CODE NO.	PROJECT CODE NO.
Columbia Falls	0480	304	05
Kalispell	0480	302	05
Scobey	0340	001	03
Missoula-Forest Fire	1100	707	05
Missoula-Lions Park	1100	019	01
Anaconda	0400	004	05
Butte-Airport	0160	032	05
Butte-Hebgen Park	0160	017	01
Billings	0080	302	05
Flathead	0480	304	05

Parameter-Code-Parameter code numbers 61310 to 61399 inclusive should be selected to retrieve all data necessary for the frequency reports.

The description of these parameter codes arelisted below for reference; however, only the range has to be coded on the select cards.

AQDHS PARAMETER-CODE

	INVERSION BASE (meters)	INVERSION THICKNESS (meters)	INVERSION TYPE	LAPSE RATE Deg/100 meters
1st INVERSION	61310	61320	61330	61340
2nd INVERSION	61311	61321	61331	61341
3rd INVERSION	61312	61322	61332	61342
4th INVERSION	61313	61323	61333	61343
5th INVERSION	61314	61324	61334	61344
6th INVERSION	61315	61325	61335	61345
7th INVERSION	61316	61326	61336	61346
8th INVERSION	61317	61327	61337	61347

	AQDHS PARAMETER CODE
AFTERNOON OR MORNING MIXING	61351
AVERAGE LAPSE RATE below 1st INVERSION (Deg C^{O}/100m)	61361
AVERAGE WINDSPEED THROUGH MIXED LAYER (m/s)	61371

	AQDHS PARAMETER-CODE	
Level	Wind Speed	Wind Direction
Surface Level	61380	61390
100 meter level	61381	61391
200 meter level	61382	61392
300 meter level	61383	61393
500 meter level	61384	61394

750 meter level	61385	18395
1000 meter level	61386	61396
1500 meter level	61387	61397
2000 meter level	61388	61398
2500 meter level	61389	61399

APPENDIX A-2

FREQUENCY SUMMARY OF UPPER LEVEL WINDS (PERCENTAGES)

LOCATION: MISSOULA - FIRE LAB - MAPS - MET.

SURFACE WINDS MORNING MAY,1979

DIRECTION	********** WIND SPEEDS METERS/SECOND **********						ROW SUMMARY		
	00.1 TO 02.9	03.0 TO 05.9	06.0 TO 09.9	10.0 TO 15.9	16.0 TO 25.0	GREATER THAN 25.0	TOTAL COUNT	TOTAL PERCENT	AVERAGE SPEED
N	15.3						2	15.3	.8
NNE	7.6						1	7.6	.9
NE							0	0.0	
ENE							0	0.0	
E	7.6						1	7.6	1.3
ESE							0	0.0	
SE							0	0.0	
SSE	7.6						1	7.6	2.2
S							0	0.0	
SSW	7.6						1	7.6	.4
SW							0	0.0	
WSW	7.6						1	7.6	1.3
W	7.6						1	7.6	.9
WNW	7.6						1	7.6	1.3
NW	7.6						1	7.6	.9
NNW	7.6						1	7.6	.9
CALM							2	15.0	
COL. TOTALS	83.7						13		.9

SURFACE WINDS AFTERNOON MAY,1979

DIRECTION	********** WIND SPEEDS METERS/SECOND **********						ROW SUMMARY		
	00.1 TO 02.9	03.0 TO 05.9	06.0 TO 09.9	10.0 TO 15.9	16.0 TO 25.0	GREATER THAN 25.0	TOTAL COUNT	TOTAL PERCENT	AVERAGE SPEED
N	22.2						2	22.2	2.4
NNE	11.1						1	11.1	2.9
NE	11.1						1	11.1	1.3
ENE							0	0.0	
E	11.1						1	11.1	1.3
ESE							0	0.0	
SE							0	0.0	
SSE							0	0.0	
S	11.1						1	11.1	.9
SSW							0	0.0	
SW		11.1					1	11.1	5.4
WSW							0	0.0	
W		11.1					1	11.1	4.0
WNW							0	0.0	
NW							0	0.0	
NNW	11.1						1	11.1	2.0
CALM							0	0.0	
COL. TOTALS	77.7	22.2					9		2.5

FREQUENCY SUMMARY OF UPPER LEVEL WINDS (PERCENTAGES)

LOCATION: MISSOULA - FIRE LAB - MAFS - MET.

1CC METER LEVEL WINDS MORNING MAY,1979

DIRECTION	********** WIND SPEEDS METERS/SECOND **********						ROW SUMMARY		
	00.1 TO 02.9	03.0 TO 05.9	06.0 TO 09.9	10.0 TO 15.9	16.0 TO 25.0	GREATER THAN 25.0	TOTAL COUNT	TOTAL PERCENT	AVERAGE SPEED
N							0	0.0	
NNE	7.6						1	7.6	.8
NE							0	0.0	
ENE	15.3						2	15.3	.8
E							0	0.0	
ESE	7.6						1	7.6	2.8
SE							0	0.0	
SSE							0	0.0	
S	15.3	7.6					3	22.9	2.0
SSW	7.6						1	7.6	1.3
SW	7.6						1	7.6	1.2
WSW							0	0.0	
W	15.3						2	15.3	.6
WNW	7.6						1	7.6	2.0
NW							0	0.0	
NNW	7.6						1	7.6	1.0
CALM							0	0.0	
COL. TOTALS	91.5	7.6					13		1.3

1CC METER LEVEL WINDS AFTERNOON MAY,1979

DIRECTION	********** WIND SPEEDS METERS/SECOND **********						ROW SUMMARY		
	00.1 TO 02.9	03.0 TO 05.9	06.0 TO 09.9	10.0 TO 15.9	16.0 TO 25.0	GREATER THAN 25.0	TOTAL COUNT	TOTAL PERCENT	AVERAGE SPEED
N		22.2					2	22.2	4.2
NNE		11.1					1	11.1	3.3
NE							0	0.0	
ENE							0	0.0	
E		11.1					1	11.1	5.0
ESE	22.2						2	22.2	1.9
SE							0	0.0	
SSE							0	0.0	
S							0	0.0	
SSW	11.1						1	11.1	1.4
SW							0	0.0	
WSW							0	0.0	
W		11.1					1	11.1	5.9
WNW							0	0.0	
NW		11.1					1	11.1	3.9
NNW							0	0.0	
CALM							0	0.0	
COL. TOTALS	33.3	66.6					9		3.5

FREQUENCY SUMMARY OF UPPER LEVEL WINDS (PERCENTAGES)

LOCATION: MISSOULA - FIRE LAB - MAFS - MET.

200 METER LEVEL WINDS MORNING MAY,1979

DIRECTION	********* WIND SPEEDS METERS/SECOND ********* 00.1 TO 02.9	03.0 TO 05.9	06.0 TO 09.9	10.0 TO 15.9	16.0 TO 25.0	GREATER THAN 25.0	ROW TOTAL COUNT	SUMMARY TOTAL PERCENT	AVERAGE SPEED
N	7.6						1	7.6	.6
NNE	7.6						1	[illegible]	1.3
NE							0	0.0	
ENE							0	0.0	
E	7.6						1	7.6	2.2
ESE	23.0						3	23.0	1.8
SE	23.0	7.6	7.6				5	38.2	3.2
SSE							0	0.0	
S							0	0.0	
SSW	7.6						1	7.6	.8
SW							0	0.0	
WSW	7.6						1	7.6	1.1
W							0	0.0	
WNW							0	0.0	
NW							0	0.0	
NNW							0	0.0	
CALM							0	0.0	
COL. TOTALS	84.0	7.6	7.6				13		2.1

200 METER LEVEL WINDS AFTERNOON MAY,1979

DIRECTION	********* WIND SPEEDS METERS/SECOND ********* 00.1 TO 02.9	03.0 TO 05.9	06.0 TO 09.9	10.0 TO 15.9	16.0 TO 25.0	GREATER THAN 25.0	ROW TOTAL COUNT	SUMMARY TOTAL PERCENT	AVERAGE SPEED
N		22.2					2	22.2	4.0
NNE							0	0.0	
NE	11.1						1	11.1	2.3
ENE							0	0.0	
E		11.1					1	11.1	4.5
ESE	11.1						1	11.1	2.8
SE	11.1						1	11.1	2.0
SSE							0	0.0	
S							0	0.0	
SSW		11.1					1	11.1	3.3
SW							0	0.0	
WSW							0	0.0	
W			11.1				1	11.1	6.5
WNW	11.1						1	11.1	2.6
NW							0	0.0	
NNW							0	0.0	
CALM							0	0.0	
COL. TOTALS	44.4	44.4	11.1				9		3.5

FREQUENCY SUMMARY OF UPPER LEVEL WINDS (PERCENTAGES)

LOCATION: MISSOULA - FIRE LAB - MAFS - MET.

300 METER LEVEL WINDS MORNING MAY,1979

DIRECTION	********* WIND SPEEDS METERS/SECOND ********* 00.1 TO 02.9	03.0 TO 05.9	06.0 TO 09.9	10.0 TO 15.9	16.0 TO 25.0	GREATER THAN 25.0	ROW TOTAL COUNT	SUMMARY TOTAL PERCENT	AVERAGE SPEED
N							0	0.0	
NNE							0	0.0	
NE							0	0.0	
ENE							0	0.0	
E	7.6						1	7.6	1.0
ESE	23.0	15.3					5	38.3	2.9
SE	15.3			7.6			3	22.9	4.6
SSE			7.6				1	7.6	6.3
S							0	0.0	
SSW							0	0.0	
SW							0	0.0	
WSW							0	0.0	
W	7.6						1	7.6	1.1
WNW		7.6					1	7.6	4.5
NW							0	0.0	
NNW		7.6					1	7.6	3.3
CALM							0	0.0	
COL. TOTALS	53.5	30.5	7.6	7.6			13		3.4

300 METER LEVEL WINDS AFTERNOON MAY,1979

DIRECTION	********* WIND SPEEDS METERS/SECOND ********* 00.1 TO 02.9	03.0 TO 05.9	06.0 TO 09.9	10.0 TO 15.9	16.0 TO 25.0	GREATER THAN 25.0	ROW TOTAL COUNT	SUMMARY TOTAL PERCENT	AVERAGE SPEED
N		22.2					2	22.2	4.9
NNE		11.1					1	11.1	3.0
NE							0	0.0	
ENE							0	0.0	
E							0	0.0	
ESE	33.3						3	33.3	2.4
SE							0	0.0	
SSE							0	0.0	
S							0	0.0	
SSW		11.1					1	11.1	3.6
SW							0	0.0	
WSW							0	0.0	
W	11.1		11.1				2	22.2	4.9
WNW							0	0.0	
NW							0	0.0	
NNW							0	0.0	
CALM							0	0.0	
COL. TOTALS	44.4	44.4	11.1				9		3.7

FREQUENCY SUMMARY OF UPPER LEVEL WINDS (PERCENTAGES)

LOCATION: MISSOULA - FIRE LAB - MAPS - MET.

500 METER LEVEL WINDS MORNING MAY,1979

DIRECTION	********* WIND SPEEDS METERS/SECOND ********* 00.1 TO 02.9	03.0 TO 05.9	06.0 TO 09.9	10.0 TO 15.9	16.0 TO 25.0	GREATER THAN 25.0	ROW TOTAL COUNT	SUMMARY TOTAL PERCENT	AVERAGE SPEED
N							0	0.0	
NNE							0	0.0	
NE							0	0.0	
ENE	7.6						1	7.6	2.1
E		7.6					1	7.6	5.0
ESE		7.6		7.6			2	15.2	7.2
SE	7.6						1	7.6	2.7
SSE	7.6	15.3					3	22.9	3.3
S							0	0.0	
SSW							0	0.0	
SW							0	0.0	
WSW							0	0.0	
W	7.6	7.6					2	15.2	3.8
WNW		7.6					1	7.6	4.7
NW		7.6	7.6				2	15.2	4.9
NNW							0	0.0	
CALM							0	0.0	
COL. TOTALS	30.4	53.3	7.6	7.6			13		4.3

500 METER LEVEL WINDS AFTERNOON MAY,1979

DIRECTION	********* WIND SPEEDS METERS/SECOND ********* 00.1 TO 02.9	03.0 TO 05.9	06.0 TO 09.9	10.0 TO 15.9	16.0 TO 25.0	GREATER THAN 25.0	ROW TOTAL COUNT	SUMMARY TOTAL PERCENT	AVERAGE SPEED
N		11.1					1	11.1	3.9
NNE		11.1					1	11.1	5.9
NE							0	0.0	
ENE							0	0.0	
E							0	0.0	
ESE	22.2						2	22.2	1.9
SE		11.1					1	11.1	3.6
SSE							0	0.0	
S							0	0.0	
SSW		11.1					1	11.1	4.6
SW							0	0.0	
WSW							0	0.0	
W							0	0.0	
WNW	11.1	11.1					2	22.2	3.3
NW							0	0.0	
NNW		11.1					1	11.1	3.7
CALM							0	0.0	
COL. TOTALS	33.3	66.6					9		3.5

FREQUENCY SUMMARY OF UPPER LEVEL WINDS (PERCENTAGES)

LOCATION: MISSOULA - FIRE LAB - MAPS - MET.

750 METER LEVEL WINDS MORNING MAY,1979

DIRECTION	********* WIND SPEEDS METERS/SECOND ********* 00.1 TO 02.9	03.0 TO 05.9	06.0 TO 09.9	10.0 TO 15.9	16.0 TO 25.0	GREATER THAN 25.0	ROW TOTAL COUNT	SUMMARY TOTAL PERCENT	AVERAGE SPEED
N							0	0.0	
NNE							0	0.0	
NE							0	0.0	
ENE							0	0.0	
E			7.6				1	7.6	7.3
ESE			7.6				1	7.6	8.0
SE	7.6		7.6				2	15.2	6.0
SSE		15.3					2	15.3	4.7
S		7.6					1	7.6	5.1
SSW							0	0.0	
SW	7.6						1	7.6	2.6
WSW			7.6				1	7.6	9.3
W		7.6	7.6				2	15.2	5.5
WNW		7.6	7.6				2	15.2	6.1
NW							0	0.0	
NNW							0	0.0	
CALM							0	0.0	
COL. TOTALS	15.2	38.1	45.6				13		5.9

750 METER LEVEL WINDS AFTERNOON MAY,1979

DIRECTION	********* WIND SPEEDS METERS/SECOND ********* 00.1 TO 02.9	03.0 TO 05.9	06.0 TO 09.9	10.0 TO 15.9	16.0 TO 25.0	GREATER THAN 25.0	ROW TOTAL COUNT	SUMMARY TOTAL PERCENT	AVERAGE SPEED
N		11.1					1	11.1	3.8
NNE							0	0.0	
NE	11.1						1	11.1	.9
ENE							0	0.0	
E	11.1						1	11.1	.9
ESE		11.1					1	11.1	4.7
SE							0	0.0	
SSE	11.1						1	11.1	.7
S	11.1						1	11.1	2.9
SSW							0	0.0	
SW							0	0.0	
WSW			11.1				1	11.1	6.0
W		11.1					1	11.1	3.4
WNW		11.1					1	11.1	4.0
NW							0	0.0	
NNW							0	0.0	
CALM							0	0.0	
COL. TOTALS	44.4	44.4	11.1				9		3.0

FREQUENCY SUMMARY OF UPPER LEVEL WINDS (PERCENTAGES)

LOCATION: MISSOULA - FIRE LAB - MAPS - MET.

1000 METER LEVEL WINDS MORNING MAY,1979

DIRECTION	********* WIND SPEEDS METERS/SECOND ********* 00.1 TO 02.9	03.0 TO 05.9	06.0 TO 09.9	10.0 TO 15.9	16.0 TO 25.0	GREATER THAN 25.0	ROW TOTAL COUNT	SUMMARY TOTAL PERCENT	AVERAGE SPEED
N							0	0.0	
NNE							0	0.0	
NE							0	0.0	
ENE							0	0.0	
E			8.3				1	8.3	6.6
ESE			8.3				1	8.3	8.1
SE		8.3					1	8.3	3.8
SSE	8.3		8.3				2	16.6	4.5
S	8.3						1	8.3	1.0
SSW							0	0.0	
SW			8.3				1	8.3	7.4
WSW			8.3				1	8.3	6.7
W							0	0.0	
WNW		8.3	8.3	8.3			3	24.9	8.4
NW			8.3				1	8.3	6.0
NNW							0	0.0	
CALM							0	0.0	
COL. TOTALS	16.6	16.6	58.1	8.3			12		6.1

1000 METER LEVEL WINDS AFTERNOON MAY,1979

DIRECTION	********* WIND SPEEDS METERS/SECOND ********* 00.1 TO 02.9	03.0 TO 05.9	06.0 TO 09.9	10.0 TO 15.9	16.0 TO 25.0	GREATER THAN 25.0	ROW TOTAL COUNT	SUMMARY TOTAL PERCENT	AVERAGE SPEED
N	11.1						1	11.1	.6
NNE							0	0.0	
NE							0	0.0	
ENE							0	0.0	
E							0	0.0	
ESE		11.1					1	11.1	3.6
SE							0	0.0	
SSE							0	0.0	
S	22.2						2	22.2	2.1
SSW							0	0.0	
SW							0	0.0	
WSW			11.1				1	11.1	7.1
W							0	0.0	
WNW		11.1		11.1			2	22.2	7.4
NW							0	0.0	
NNW	11.1	11.1					2	22.2	3.2
CALM							0	0.0	
COL. TOTALS	44.4	33.3	11.1	11.1			9		4.0

FREQUENCY SUMMARY OF UPPER LEVEL WINDS (PERCENTAGES)

LOCATION: MISSOULA - FIRE LAB - MAFS - MET.

1500 METER LEVEL WINDS MORNING MAY,1979

DIRECTION	********* WIND SPEEDS METERS/SECOND *********						ROW	SUMMARY	
	00.1 TO 02.9	03.0 TO 05.9	06.0 TO 09.9	10.0 TO 15.9	16.0 TO 25.0	GREATER THAN 25.0	TOTAL COUNT	TOTAL PERCENT	AVERAGE SPEED
N							0	0.0	
NNE							0	0.0	
NE							0	0.0	
ENE							0	0.0	
E	8.3						1	8.3	2.7
ESE							0	0.0	
SE		8.3					1	8.3	4.6
SSE			8.3				1	8.3	8.9
S							0	0.0	
SSW							0	0.0	
SW							0	0.0	
WSW		8.3		8.3			2	16.6	9.1
W		8.3			8.3		2	16.6	11.5
WNW							0	0.0	
NW		8.3		8.3			2	16.6	8.6
NNW		16.6	8.3				3	24.9	4.5
CALM							0	0.0	
COL. TOTALS	8.3	49.8	16.6	16.6	8.3		12		7.3

1500 METER LEVEL WINDS AFTERNOON MAY,1979

DIRECTION	********* WIND SPEEDS METERS/SECOND *********						ROW	SUMMARY	
	00.1 TO 02.9	03.0 TO 05.9	06.0 TO 09.9	10.0 TO 15.9	16.0 TO 25.0	GREATER THAN 25.0	TOTAL COUNT	TOTAL PERCENT	AVERAGE SPEED
N		11.1					1	11.1	3.1
NNE							0	0.0	
NE							0	0.0	
ENE							0	0.0	
E							0	0.0	
ESE							0	0.0	
SE							0	0.0	
SSE			11.1				1	11.1	6.8
S		11.1					1	11.1	3.8
SSW							0	0.0	
SW							0	0.0	
WSW				11.1			1	11.1	10.5
W							0	0.0	
WNW			11.1		11.1		2	22.2	12.3
NW		11.1	11.1				2	22.2	6.2
NNW		11.1					1	11.1	3.7
CALM							0	0.0	
COL. TOTALS		44.4	33.3	11.1	11.1		9		7.2

FREQUENCY SUMMARY OF UPPER LEVEL WINDS (PERCENTAGES)

LOCATION: MISSOULA - FIRE LAB - MAFS - MET.

2000 METER LEVEL WINDS MORNING MAY,1979

DIRECTION	********* WIND SPEEDS METERS/SECOND ********* 00.1 TO 02.9	03.0 TO 05.9	06.0 TO 09.9	10.0 TO 15.9	16.0 TO 25.0	GREATER THAN 25.0	ROW TOTAL COUNT	SUMMARY TOTAL PERCENT	AVERAGE SPEED
N							0	0.0	
NNE		9.0					1	9.0	4.6
NE							0	0.0	
ENE			9.0				1	9.0	6.3
E							0	0.0	
ESE							0	0.0	
SE							0	0.0	
SSE							0	0.0	
S							0	0.0	
SSW							0	0.0	
SW			9.0				1	9.0	6.7
WSW				9.0			1	9.0	13.6
W				9.0			1	9.0	15.0
WNW				9.0			1	9.0	12.3
NW	9.0		9.0	9.0			3	27.0	7.9
NNW			18.1				2	18.1	7.2
CALM							0	0.0	
COL. TOTALS	9.0	9.0	45.1	36.0			11		8.7

2000 METER LEVEL WINDS AFTERNOON MAY,1979

DIRECTION	********* WIND SPEEDS METERS/SECOND ********* 00.1 TO 02.9	03.0 TO 05.9	06.0 TO 09.9	10.0 TO 15.9	16.0 TO 25.0	GREATER THAN 25.0	ROW TOTAL COUNT	SUMMARY TOTAL PERCENT	AVERAGE SPEED
N							0	0.0	
NNE	12.5						1	12.5	1.1
NE							0	0.0	
ENE							0	0.0	
E							0	0.0	
ESE							0	0.0	
SE							0	0.0	
SSE							0	0.0	
S							0	0.0	
SSW							0	0.0	
SW	12.5						1	12.5	1.7
WSW			12.5				1	12.5	8.2
W			12.5	12.5			2	25.0	11.9
WNW			25.0				2	25.0	7.9
NW							0	0.0	
NNW			12.5				1	12.5	6.3
CALM							0	0.0	
COL. TOTALS	25.0		62.5	12.5			8		7.1

FREQUENCY SUMMARY OF UPPER LEVEL WINDS (PERCENTAGES)

LOCATION: MISSOULA - FIRE LAB - MAPS - MET.

2500 METER LEVEL WINDS MORNING MAY,1979

DIRECTION	********* WIND SPEEDS METERS/SECOND ********* 00.1 TO 02.9	03.0 TO 05.9	06.0 TO 09.9	10.0 TO 15.9	16.0 TO 25.0	GREATER THAN 25.0	ROW TOTAL COUNT	SUMMARY TOTAL PERCENT	AVERAGE SPEED
N							0	0.0	
NNE							0	0.0	
NE							0	0.0	
ENE							0	0.0	
E							0	0.0	
ESE							0	0.0	
SE							0	0.0	
SSE							0	0.0	
S							0	0.0	
SSW							0	0.0	
SW							0	0.0	
WSW							0	0.0	
W							0	0.0	
WNW							0	0.0	
NW							0	0.0	
NNW							0	0.0	
CALM							0	0.0	
COL. TOTALS							0		

2500 METER LEVEL WINDS AFTERNOON MAY,1979

DIRECTION	********* WIND SPEEDS METERS/SECOND ********* 00.1 TO 02.9	03.0 TO 05.9	06.0 TO 09.9	10.0 TO 15.9	16.0 TO 25.0	GREATER THAN 25.0	ROW TOTAL COUNT	SUMMARY TOTAL PERCENT	AVERAGE SPEED
N							0	0.0	
NNE							0	0.0	
NE							0	0.0	
ENE							0	0.0	
E							0	0.0	
ESE							0	0.0	
SE							0	0.0	
SSE							0	0.0	
S							0	0.0	
SSW		20.0					1	20.0	5.1
SW							0	0.0	
WSW							0	0.0	
W	20.0				20.0		2	40.0	9.7
WNW			40.0				2	40.0	8.0
NW							0	0.0	
NNW							0	0.0	
CALM							0	0.0	
COL. TOTALS	20.0	20.0	40.0		20.0		5		8.1

FREQUENCY SUMMARY OF INVERSIONS (PERCENTAGES)

LOCATION: MISSOULA - FIRE LAB - MAFS - MET.

MONTH OF MAY 1979 MORNING

THICKNESS (METERS)	INVERSION BASE HEIGHT (METERS) SFC	001 TO 100	101 TO 250	251 TO 500	501 TO 750	751 TO 1000	1001 TO 1500	1501 TO 2000	2001 TO 2500	2501 TO 3000	> THAN 3000	TOTAL
001-100	8.3	5.5	5.5	11.1		5.5	2.7	2.7				41.3
101-250	13.8	5.5	8.3	8.3	11.1		8.3					55.3
251-500	2.7											2.7
501-750												
TOTAL	24.8	11.0	13.8	19.4	11.1	5.5	11.0	2.7				
NO INVERSION												0.0
								TOTAL NO. OF OCCURENCES				36
INVERSION TYPE												
1	2.7	8.3	5.5	11.1	5.5	5.5	8.3	2.7				49.6
2		2.7	8.3	8.3	5.5		2.7					27.5
3	19.4											19.4
4	2.7											2.7
5												

MONTH OF MAY 1979 AFTERNOON

THICKNESS (METERS)	INVERSION BASE HEIGHT (METERS) SFC	001 TO 100	101 TO 250	251 TO 500	501 TO 750	751 TO 1000	1001 TO 1500	1501 TO 2000	2001 TO 2500	2501 TO 3000	> THAN 3000	TOTAL
001-100				12.5			25.0					37.5
101-250												
251-500												
501-750												
TOTAL				12.5			25.0					
NO INVERSION												62.0
								TOTAL NO. OF OCCURENCES				3
INVERSION TYPE												
1							66.6					66.6
2												
3				33.3								33.3
4												
5												

FREQUENCY SUMMARY OF MIXING HEIGHTS

LOCATION: MISSOULA - FIRE LAB - MAFS - MET.

MIXING HEIGHTS -FREQUENCY OF OCCURENCE FOR MAY 1979

MIXING HEIGHT (METERS)	MORNING OCCURENCES	AFTERNOON OCCURENCES
0- 100	4	0
101- 250	4	0
251- 500	4	0
501- 750	0	1
751-1000	1	2
1001-1500	0	1
>1500	0	4
TOTAL	13	8

AVERAGE WIND SPEED THROUGH MIXED LAYER (M/SEC)	1.8	4.4
AVERAGE LAPSE RATE BELOW FIRST INVER. (DEG C /100M)	-00.56	-00.50

UPPER AIR PILOT BALLOON DATA COMPUTER ANALYSIS

USER MANUAL

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For: The Department of Health and Environmental Sciences
Air Quality Bureau

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CHAPTER 1

General Method of Analysis

The computer system analyzes on pilot balloon tracking runs conducted at various sites in Montana. The data is recorded during the run on predesigned coding forms. Examples can be found in Appendix A-3 and the type of information recorded is self-explanatory.

Basically the pilot balloon is tracked by one or two theodolites positioned at two established points (A and B) on the ground. Elevation and azimuth angles are recorded at predetermined time intervals. With this data, the computer calculates the coordinate position of the balloon at each interval of time or height. Wind speed and wind direction are then computed by assuming a straight line change from one coordinate position to the next.

The current version of the program allows various tracking arrangements in the field. One arrangement is to use a single theodolite located at release point A or B and the balloon released at either A or B with recordings of azimuth and altitude taken at some predetermined time interval (usually 30 seconds).

For single theodolite tracking, a constant ascent rate is assumed and is used for calculations inthe program where the ascent rate depends on the balloon number entered on the code sheet. The program uses the following ascent rates:

Balloon No. Coded	Ascent Rate Use by the Program
1	542 feet/min
2	351 feet/min
3	252 feet/min
4	151 feet/min

Two theodolites may be used to track the balloon. In this case identical coding sheets are recorded for each theodolite. Again the program allows the tracking method to have the balloon released at either A or B theodolite stations. No provisions are in the current program to allow the balloon to be released at other than station A or B. The program makes the necessary corrections based on the coordinate positions of A and B so the release point for the balloon has X and Y coordinate values of zero.

The method of analysis for double theodolite tracking is adapted from a 3 dimensional vector algebra scheme written by Norman Thyer.[1]

The mathematical approach is to calculate the intersection made by two vector-described directions. One direction is a straight line from station A to the balloon and the other direction is the vector from stations A to B plus the vector from B to the balloon. The two vectors representing the two theodolite rays will not always intersect and instead the rays will approach one another within the shortest distance. This represents the error of closure between the two theodolite rays and also represents the most probable location of the balloon.

Thyer's method restricted the baseline (A to B) to be directly north-south. The mathematics were modified in this program to allow the baseline to be in any direction. The coordinate description for the baseline is required input to this program and is coded on the title card and described in detail in Part 2 of this report.

---

[1] "Double Theodolite Pibal Evaluation by Computer" by Norman Thyer, 1961, Journal of Applied Meteorology, Volume 1, pg. 66-68.

The current version of the program sets two limits on the accuracy of closure on the balloon for the two theodolite readings:

1. If the closure error is greater than 10 meters, the data recorded for that level is dropped.
2. When the calculated height becomes greater than 1000 meters, the double theodolite method is discontinued and the single theodolite method is used for the remaining levels.

These two accuracy controls were established by observing the results of various simulated trial data runs through the double analysis. An analytical approach to this error analysis is difficult to make due to many variables among which are theodolite reading errors, faulty synchronization of the readings, too short of a baseline between tracking stations, position of the balloon which can create sensitive or weak angles, and computer number truncation and precision.

Probably the most critical requirement for successful double theodolite analysis is a relatively large and accurately established baseline. Most of the sites currently use a 100 meter baseline. A 500 meter baseline would improve considerably the accuracy of the analysis. Current methods in the field require communication and synchronized timing signals between the two stations, making it difficult to establish longer baselines at the present sites.

The program provides interpolation at heights where either the input values or calculated values are found to be unreasonable. If it is required to interpolate through more than three consecutive levels, the run is discontinued at the program branches to the next run.

No extrapolation is made by the program if the highest levels calculated result in unreasonable values. These are dropped from the analysis and the report will show results up the last good level.

Provisions are made in the program to accept a different number of levels recorded for each theodolite in a double theodolite run. In this case the double analysis method is performed up to the one with the smallest number of levels (either A or B) and a single analysis is performed from this point to the highest level recorded on the other.

In the double theodolite analysis routine, if it is found that more than two consecutive levels were dropped due to the closure limit, the program begins a single theodolite analysis at the next level past the last accepted double theodolite level. The output report documents where this change takes place (see Appendix A-3 for example report).

The current version of the program allows up to 40 levels (41 levels including the surface level) on either single or double theodolite runs.

A temperature analysis is made by the program if the balloon tracked included a temperature sonde. The recordings are made on the appropriate form (see Appendix A-3). A flag to indicate that temperature data follows is coded on the pilot balloon coding form. A maximum of 100 temperature recordings is allowed. If an unreasonable value is detected in the analysis, the level is dropped and the analysis adjusts the elapsed time and continues to the next level. The number of levels dropped is noted in the output reports.

In summary, the program analysis generates a three page report for each balloon tracking run.

The first page shows the calculated coordinate position of the balloon, the wind speed, and the wind direction for each level.

The second page shows the temperature analysis if temperature data was input. The report includes the time elapsed, the recorded temperature, the height above ground level and the lapse rate for each level.

The third page of the report shows the calculated inversion base heights, and thicknesses and type of nversions based on Holzworth's classification scheme. This is followed by the calculated morning or afternoon mixing heights, the average lapse rate below the first inversion layer if the first inversion was not sfc-based, and the average wind speed through the mixed layer. The third page also shows the wind speed and direction at fixed elevations of 100, 200, 300, 500, 750, 1000, 1500, 2000, and 2500 meters. The highest level shown depends on the input data recorded.

All data values shown on the third page are transferred to the AQDHS data storage file and the details of this process are described in Chapter 4 of this appendix.

CHAPTER 2

Input Data Preparation

Pilot Balloon Computer Forms (See Appendix A-3)

There are two formats which the program will accept for the pilot balloon tracking data. They are marked "NEW FORMAT" and "OLD FORMAT."

NEW FORMAT:

No decimal points are coded and numbers are aligned in the field with the assumed decimal located as shown in the field.

Col.	Field	Type	Description	Remarks
1-2	99^	Numeric	Year	
3-4	99^	Numeric	Month	Code leading zeroes
5-6	99^	Numeric	Day	Code leading zeroes
7-10	9999^	Numeric	Hour (MST)	Military hour - Code leading zeroes
11	X	Non-numeric	Release Point "A" or "B"	Depending on which point the balloon is released from
12	9^	Numeric	No. of Theodolites Used Code "1" or "2"	If 2 is coded then
13	9^	Numeric	Balloon Type Code "1", "2" "3", "4"	Balloon type code is explained in part 1 of this manual.
14-15	99^	Numeric	T in seconds	The timing interval used for the tracking run.
16-17	99^	Numeric	Highest Level Recorded	Maximum is 50 leading zeroes can be left blank
18	9^	Numeric	Study	See Parameter Codes - Chapter 4.

Col.	Field	Type	Description	Remarks
19	9^	Numeric	Site	See Parameter Codes, Chapter 4.
20-23	*NOT USED*			
24	9^	Numeric	T-Sonde Flag Code "1" or (0 or) Blank	A "1" indicates temperature data was recorded for this run.
25	X	Non-numeric	Code "A" or "B" depending on which station theodolite is on.	
26-27	99^	Numeric	Code "pp"	Precoded level indicating surface level.
28-32	999^99	Numeric	Surface wind direction in decimal degrees.	Leading zeroes can be left blank.
33-36	99^99	Numeric	Surface wind speed in m/sec.	Leading zeroes can be left blank.
37-38	99/	Numeric	Precoded level no.	
39-43	999^99	Numeric	Azimuth Reading (Decimal Degrees)	Leading zeroes can be left blank.
44-47	99^99	Numeric	Elevation Reading (Decimal Degrees)	Leading zeroes can be left blank.

The remaining entries on the code sheet are coded similar to columns 37 through 47. Highest level allowed is No. 39.

OLD FORMAT: (See Appendix A-3)

The field entries and descriptions are identical to the New Format. The difference is in the arrangement of the level, azimuth and elevation entries. Note that there is room for 14 levels and additional coding sheets will have to be used for higher levels. Note also that the level numbers are not precoded and that the surface wind direction and speed at level 00 have to be repeated, along with Cols. 1 through 25 on additional coding sheets if required.

Temperature Sonde Computer Form (See Appendix A)

FORMAT:

No decimal points are coded and numbers are aligned in the field with the assumed decimal located as shown in the field.

Col.	Field	Type	Description	Remarks
1-3	XXX	Non-numeric	Study Area	See Parameter Codes. Chapter 4.
4-5	99	Numeric	Year	
6-7	99	Numeric	Month	
8-9	99	Numeric	Day	
10-13	9999	Numeric	Hour (MST)	Military hour. Code leading zeroes.
14	9	Numeric	Balloon Number	Same as on Pibal Coding Form
15-17	999	Numeric	Highest level recorded.	Maximum 100 levels
18-21	±999 9	Numeric	Surface Temperature	Code minus sign if needed left of most significant digit. Plus sign is optional. Leading zeroes can be left blank.
22	9	Numeric	Temperature Scale	Code 1 for Centigrade 2 for Fahrenheit 3 for Kelvin
23-26	±999 9	Numeric	Maximum Surface Temperature	Code the maximum temperature of the day, if the run is made in the afternoon. Code sfc. temp. $+3^{o}C$. if a morning run. Plus sign is optional.
27-29	999	Numeric	Level Number	Leading zeroes can be left blank.
30-33	±999 9	Numeric	Temperature recorded for given level.	Plus sign optional. Leading zeroes can be left blank. Code minus sign left of most significant digit.
34-35	99	Numeric	Time interval in seconds since last level recordings.	Leading zeroes can be left blank.

Repeat columns 27 through 35 coding procedures for the remaining portion of the code sheet. Recording of each level should be coded in ascending order by level number, working from left to right in row fashion.

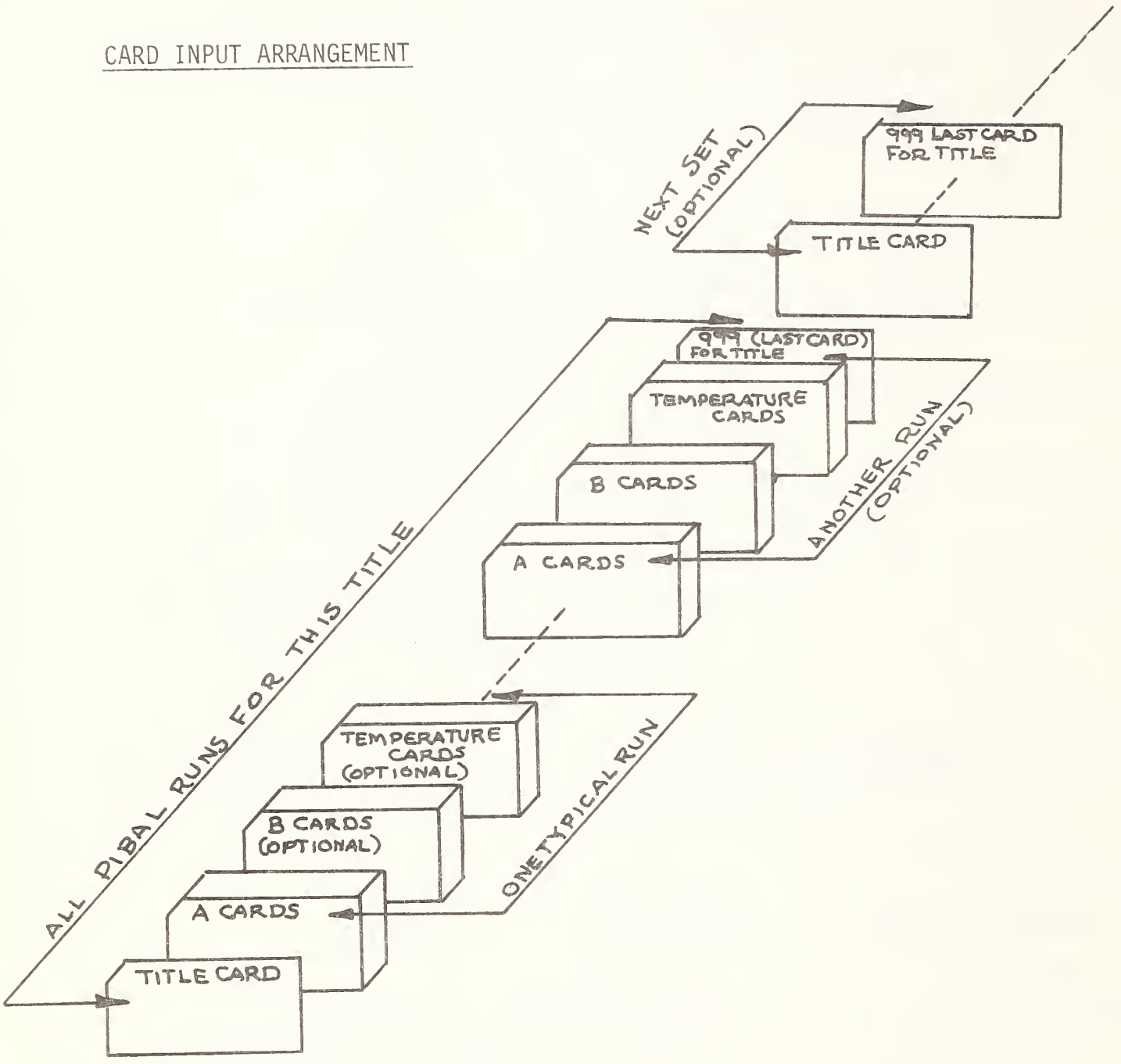
Title Card Format

Col.	Field	Type	Description	Remarks
1-40	X(w)	Non-numeric	Site Description	Used for the title on output reports.
41-50	±9999999^99	Numeric	Baseline X Coordinate	The baseline coordinates (columns 41 through 70) are the coordinate offsets from Station A to Station B. Plus sign is optional. Values can optionally be coded with the decimal point anywhere within the 10 column field. Leading zeroes may be left blank.
51-60	±9999999^99	Numeric	Baseline Y Coordinate	
61-70	±9999999^99	Numeric	Baseline Z Coordinate	
71-79	*NOT USED*			
80	X	Non-numeric	Code "N" or "X" N = New Format X = Old Format	Flag to indicate whether the Pibal Coding Form is the New Format or Old Format

Last Card Format

Col.	Field	Type	Description	Remarks
1-19	*NOT USED*		Leave Blank	
20-23	9999	Numeric	Code "9999"	Last card flag. All cards between this card and the Title Card constitute a computer run for that Title.
24-80	*NOT USED*		Leave Blank	

CARD INPUT ARRANGEMENT



CHAPTER 3

Data Flow Through System

There are three programs and one cataloged procedure in the system:

1. Program AIRED313: This program inputs the card data, edits it and produces an error report (example in Appendix A-3). The cards in error are corrected and recycled through AIRED313. Recycled data must include all A, B and temperature cards which make up a single pilot balloon tracking run.

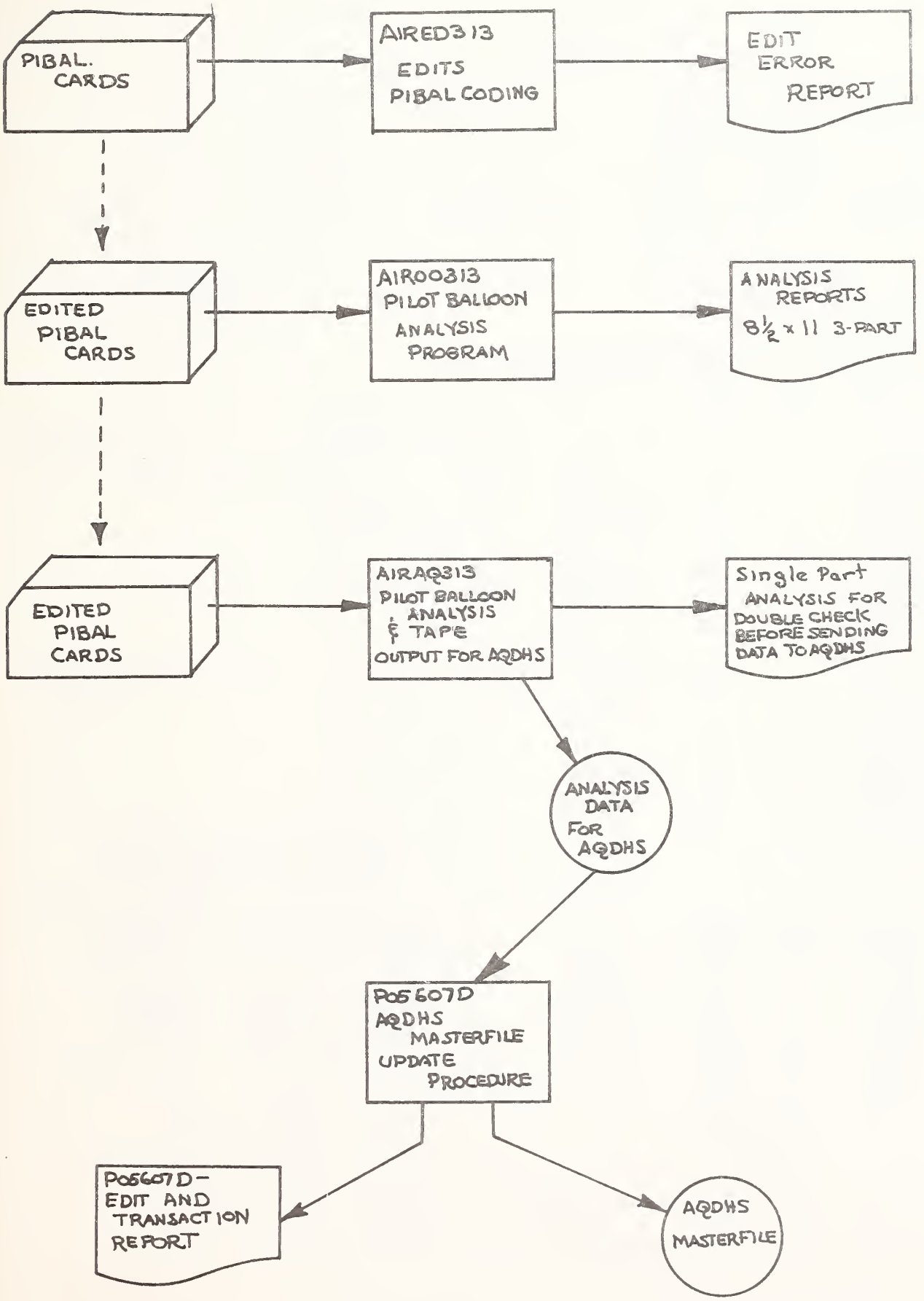
2. Program AIR00313: This program inputs the edited card deck and produces a 3-part 8½ x 11 output analysis report (example in Appendix A-3).

3. Program AIRAQ313: This program is basically the same as Program AIR00313 but with additional instructions that generate an output magtape containing the necessary parameters and upper air data in a format required for input to the AQDHS Data Bank. The program inputs the edited card deck as in Program AIR00313. In addition, the program outputs a single report identical to the report generated in AIR00313. This output is used to double check the analysis before updating the AQDHS Data Bank with the magtape. The data set name for this tape is "Balloon Data."

4. Procedure P05607D: This procedure inputs the magtape containing the upper air analysis data that was generated by Program AIRAQ313 to the AQDHS Data Bank. For details of this procedure, see the Montana AQDHS Procedure Manual.

The following is a schematic of the data flow for the upper air analysis system:

DATA FLOW THROUGH SYSTEM


PIBAL. CARDS
AIRED313 EDITS PIBAL CODING
EDIT ERROR REPORT
EDITED PIBAL CARDS
AIR00313 PILOT BALLOON ANALYSIS PROGRAM
ANALYSIS REPORTS 8½ x 11 3-PART
EDITED PIBAL CARDS
AIRAQ313 PILOT BALLOON ANALYSIS & TAPE OUTPUT FOR AQDHS
Single Part ANALYSIS FOR DOUBLE CHECK BEFORE SENDING DATA TO AQDHS
ANALYSIS DATA FOR AQDHS
P05607D AQDHS MASTERFILE UPDATE PROCEDURE
P05607D - EDIT AND TRANSACTION REPORT
AQDHS MASTERFILE

CHAPTER 4

Parameter Codes Used for AQDHS

All data values that are reported on the third sheet of the output report (Appendix A-3) are written to the magtape created by Program AIRAQ313. This file is formated to satisfy the requirements of transaction Format 1 for AQDHS.

The following are the Parameter Codes used:

		Remarks
Form Code	"1"	Transaction Form Code
State Code	"27"	Montana
Agency Code	"F"	
Time Code	"7"	
Status Flag	"S"	
Action Code	"2"	
Method Code	"11"	
Start Hour Code		Two digit military hour rounded to nearest hour. (See note following.)

Pilot Balloon Coding			Values Generated for AQDHS		
Study	Site	Location	Area Code	Site Code	Project Code
1	1	Columbia Falls	0480	304	05
1	2	Kalispell	0480	302	05
2	1	Scobey	0340	001	03
3	1	Missoula-Forest Fire	1100	707	05
3	2	Missoula-Lions Park	1100	019	01

Study	Site	Location	Area Code	Site Code	Project Code
4	1	Anaconda	0400	004	05
5	1	Butte-Airport	0160	302	05
5	2	Butte-Hebgen Park	0160	017	01
6	1	Billings	0080	302	05
7	1	Flathead	0480	304	05

Description of Values Calculated in Program AIRAQ313		Associated AQDHS Parameter Codes Generated			
		Parameter Code	Unit Code	DP	Data Field
Inversion Base (meters)	1st Inversion	61310	57	0	9999
	2nd Inversion	61311	57	0	9999
	3rd Inversion	61312	57	0	9999
	4th Inversion	61313	57	0	9999
	5th Inversion	61314	57	0	9999
	6th Inversion	61315	57	0	9999
	7th Inversion	61316	57	0	9999
	8th Inversion	61317	57	0	9999
Inversion Thickness (meters)	1st Inversion	61320	57	0	9999
	2nd Inversion	61321	57	0	9999
	3rd Inversion	61322	57	0	9999
	4th Inversion	61323	57	0	9999
	5th Inversion	61324	57	0	9999
	6th Inversion	61325	57	0	9999
	7th Inversion	61326	57	0	9999
	8th Inversion	61327	57	0	9999
Inversion Type	1st Inversion	61330	59	0	0009
	2nd Inversion	61331	59	0	0009
	3rd Inversion	61332	59	0	0009
	4th Inversion	61333	59	0	0009
	5th Inversion	61334	59	0	0009
	6th Inversion	61335	59	0	0009
	7th Inversion	61336	59	0	0009
	8th Inversion	61337	59	0	0009

Lapse Rate (Degrees/100 meters)	1st Inversion	61340	58	3	9^999
	2nd Inversion	61341	58	3	9^999
	3rd Inversion	61342	58	3	9^999
	4th Inversion	61343	58	3	9^999
	5th Inversion	61344	58	3	9^999
	6th Inversion	61345	58	3	9^999
	7th Inversion	61346	58	3	9^999
	8th Inversion	61347	58	3	9^999
Afternoon or Morning Mixing Height (Meters)		61351	57	0	9999
Average Lapse Rate Below First Inversion (Degrees C^{O}/100 m)		61361	58	2	99^99
Average wind speed through mixed layer (meters/second)		61371	11	1	999^9
Wind Speed (meters/second)	Surface Level	61380	11	1	999^9
	100 meter level	61381	11	1	999^9
	200 meter level	61382	11	1	999^9
	300 meter level	61383	11	1	999^9
	500 meter level	61384	11	1	999^9
	750 meter level	61385	11	1	999^9
	1000 meter level	61386	11	1	999^9
	1500 meter level	61387	11	1	999^9
	2000 meter level	61388	11	1	999^9
	2500 meter level	61389	11	1	999^9
Wind Direction (Decimal Degrees)	Surface level	61390	14	1	999^9
	100 meter level	61391	14	1	999^9
	200 meter level	61392	14	1	999^9
	300 meter level	61393	14	1	999^9
	500 meter level	61394	14	1	999^9
	750 meter level	61395	14	1	999^9
	1000 meter level	61396	14	1	999^9
	1500 meter level	61397	14	1	999^9
	2000 meter level	61398	14	1	999^9
	2500 meter level	61399	14	1	999^9

Note: Since the pibal field runs are made once in the morning and once in the afternoon, it was decided that Format 1 transaction form using Time Code "7" would best accommodate the upper air data. This way two data fields per parameter code are stored per record on AQDHS. The first data field is the morning value and the second value is the afternoon value. The current

AQDHS update programs, however, generate an invalid or misleading start hour under certain conditions. For example, if for a given day no morning run was made but the afternoon run was made, AQDHS generates a start hour of "02" filling the first data field with 9999's and the proper data value in the second field. If later morning data is added to the file, the morning value goes into the first data field correctly but the start hour remains at "02." There are other combinations causing the start hour to be misleading, however, it is manageable since the start hour can be disregarded with the understanding that the first data value is the correct morning value and the second value is the correct afternoon value.

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PILOT BALLOON COMPUTER FORM

YEAR [ ][ ] 1 2
MONTH [ ][ ] 3 4
DAY [ ][ ] 5 6
HOUR(MST) [ ][ ][ ][ ] 7 8 9 10
RELEASE POINT [ ] 11
NO. THEODOLITES [ ] 12
BALLOON NO. [ ] 13
ΔT(SEC) [ ][ ] 14 15
HIGHEST LEVEL RECORDED [ ][ ] 16 17
STUDY [ ] 18
SITE [ ] 19
CORR. TERM (DEGREES) [ ][ ][ ][ ] 20 21 22 23
T-SONDE (1=YES) [ ] 24
TRACKING STATION [ ] 25

	SURFACE WIND DIRECTION	SURFACE WIND SPEED (M/S)
0 0 (26 27)	[ ][ ][ ][ ][ ] 28 32	[ ][ ][ ][ ] 33 36

LEVEL NO.	AZIMUTH	ELEVATION
[ ][ ] 37 38	[ ][ ][ ][ ][ ] 39 43	[ ][ ][ ][ ] 44 47
[ ][ ] 48 49	[ ][ ][ ][ ][ ] 50 54	[ ][ ][ ][ ] 55 58
[ ][ ] 59 60	[ ][ ][ ][ ][ ] 61 65	[ ][ ][ ][ ] 66 69
[ ][ ] 70 71	[ ][ ][ ][ ][ ] 72 76	[ ][ ][ ][ ] 77 80

LEVEL NO.	AZIMUTH	ELEVATION
[ ][ ] 26 27	[ ][ ][ ][ ][ ] 28 32	[ ][ ][ ][ ] 33 36

LEVEL NO.	AZIMUTH	ELEVATION
[ ][ ] 26 27	[ ][ ][ ][ ][ ] 28 32	[ ][ ][ ][ ] 33 36
[ ][ ] 37 38	[ ][ ][ ][ ][ ] 39 43	[ ][ ][ ][ ] 44 47
[ ][ ] 48 49	[ ][ ][ ][ ][ ] 50 54	[ ][ ][ ][ ] 55 58
[ ][ ] 59 60	[ ][ ][ ][ ][ ] 61 65	[ ][ ][ ][ ] 66 69
[ ][ ] 70 71	[ ][ ][ ][ ][ ] 72 76	[ ][ ][ ][ ] 77 80

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PILOT BALLOON COMPUTER FORM

YEAR	MONTH	DAY	HOUR (MST)	RELEASE POINT	NO. THEODOLITES	BALLOON NO.	ΔT(SEC)	HIGHEST LEVEL RECORDED	STUDY	SITE	CORR. TERM (DEGREES)	T-SONDE (1=YES)	TRACKING STATION
1 2	3 4	5 6	7 8 9 10	11	12	13	14 15	16 17	18	19	20 21 22 23	24	25

	SURFACE WIND DIRECTION	SURFACE WIND SPEED (M/S)	LEVEL NO.	AZIMUTH	ELEVATION	LEVEL NO.	AZIMUTH	ELEVATION	LEVEL NO.	AZIMUTH	ELEVATION
0 0	26 27 28 29 30 31 32	33 34 35 36	1 0	26 27 28 29 30 31 32	33 34 35 36	2 0	26 27 28 29 30 31 32	33 34 35 36	3 0	26 27 28 29 30 31 32	33 34 35 36
LEVEL NO.	AZIMUTH	ELEVATION									
0 1	37 38 39 40 41 42 43	44 45 46 47	1 1	37 38 39 40 41 42 43	44 45 46 47	2 1	37 38 39 40 41 42 43	44 45 46 47	3 1	37 38 39 40 41 42 43	44 45 46 47
0 2	48 49 50 51 52 53 54	55 56 57 58	1 2	48 49 50 51 52 53 54	55 56 57 58	2 2	48 49 50 51 52 53 54	55 56 57 58	3 2	48 49 50 51 52 53 54	55 56 57 58
0 3	59 60 61 62 63 64 65	66 67 68 69	1 3	59 60 61 62 63 64 65	66 67 68 69	2 3	59 60 61 62 63 64 65	66 67 68 69	3 3	59 60 61 62 63 64 65	66 67 68 69
0 4	70 71 72 73 74 75 76	77 78 79 80	1 4	70 71 72 73 74 75 76	77 78 79 80	2 4	70 71 72 73 74 75 76	77 78 79 80	3 4	70 71 72 73 74 75 76	77 78 79 80
0 5	26 27 28 29 30 31 32	33 34 35 36	1 5	26 27 28 29 30 31 32	33 34 35 36	2 5	26 27 28 29 30 31 32	33 34 35 36	3 5	26 27 28 29 30 31 32	33 34 35 36
0 6	37 38 39 40 41 42 43	44 45 46 47	1 6	37 38 39 40 41 42 43	44 45 46 47	2 6	37 38 39 40 41 42 43	44 45 46 47	3 6	37 38 39 40 41 42 43	44 45 46 47
0 7	48 49 50 51 52 53 54	55 56 57 58	1 7	48 49 50 51 52 53 54	55 56 57 58	2 7	48 49 50 51 52 53 54	55 56 57 58	3 7	48 49 50 51 52 53 54	55 56 57 58
0 8	59 60 61 62 63 64 65	66 67 68 69	1 8	59 60 61 62 63 64 65	66 67 68 69	2 8	59 60 61 62 63 64 65	66 67 68 69	3 8	59 60 61 62 63 64 65	66 67 68 69
0 9	70 71 72 73 74 75 76	77 78 79 80	1 9	70 71 72 73 74 75 76	77 78 79 80	2 9	70 71 72 73 74 75 76	77 78 79 80	3 9	70 71 72 73 74 75 76	77 78 79 80

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AIR QUALITY BUREAU
TEMPERATURE SONDE COMPUTER FORM

1 = Centigrade
2 = Fahrenheit
3 = Kelvin

STUDY AREA (1 2 3)

YEAR (4 5) MONTH (6 7) DAY (8 9) HOUR (MST) (10 11 12 13) BALLOON NO. (14) HIGHEST LEVEL RECORDED (15 16 17) SURFACE TEMP. (18 19 20 21) TEMP. SCALE (22) Max. T (AM use T + 3.0C) (23 24 25 26)

LEVEL NO. (27 28 29)	TEMP. (30 31 32 33)	TIME INT.(SEC) (34 35)	LEVEL NO. (36 37 38)	TEMP. (39 40 41 42)	TIME INT.(SEC) (43 44)	LEVEL NO. (45 46 47)	TEMP. (48 49 50 51)	TIME INT.(SEC) (52 53)

BUTTE AIRPORT UPPER AIR SUMMARY

DATE: 790601 HOUR: 510 ASCENT RATE (M/SEC): 1.78

LEVEL NO.	TIME SINCE RELEASE (MIN)	LOCATION Z (M)	X (KM)	Y (KM)	AVER LAYER WIND SPEED (M/SEC)	AVER LAYER WIND DIR (DEG)	
1	0.0	0.	0.0	0.0	0.9	180.	S
2	0.5	54.	0.0	0.04	1.5	180.	I
3	1.0	107.	0.0	0.09	1.5	180.	S
4	1.5	161.	-0.02	0.10	0.7	117.	S
5	2.0	214.	0.02	0.09	1.2	277.	S
6	2.5	268.	0.06	0.10	1.5	258.	S
7	3.0	321.	0.07	0.11	0.3	258.	S
8	3.5	375.	0.07	0.09	0.5	16.	S
9	4.0	428.	0.06	0.07	0.8	16.	S
10	4.5	482.	0.09	0.05	0.9	302.	S
11	5.0	535.	0.15	0.06	2.1	263.	S
12	5.5	589.	0.23	0.09	2.9	245.	S
13	6.0	642.	0.35	0.13	4.2	254.	S
14	6.5	696.	0.46	0.13	3.8	267.	S
15	7.0	749.	0.57	0.12	2.5	278.	S
16	7.5	803.	0.67	0.09	2.4	285.	S
17	8.0	856.	0.77	0.05	3.8	290.	S
18	8.5	910.	0.89	0.00	4.1	293.	S
19	9.0	963.	1.01	-0.05	4.3	294.	S
20	9.5	1017.	1.14	-0.11	4.6	297.	S
21	10.0	1070.	1.27	-0.20	5.3	302.	S
22	10.5	1124.	1.42	-0.30	5.5	303.	S
23	11.0	1177.	1.57	-0.39	6.0	302.	S
24	11.5	1231.	1.71	-0.49	5.8	306.	S
25	12.0	1284.	1.88	-0.60	6.7	301.	S
26	12.5	1338.	2.07	-0.70	7.0	299.	S
27	13.0	1391.	2.25	-0.80	7.0	299.	S
28	13.5	1445.	2.44	-0.88	6.9	294.	S
29	14.0	1498.	2.64	-0.98	7.4	295.	S
30	14.5	1552.	2.85	-1.08	7.6	296.	S
31	15.0	1605.	3.04	-1.18	7.3	298.	S
32	15.5	1659.	3.23	-1.28	7.2	298.	S
33	16.0	1712.	3.43	-1.39	7.7	300.	S
34	16.5	1766.	3.65	-1.51	8.1	299.	S
35	17.0	1819.	3.88	-1.63	8.6	298.	S
36	17.5	1873.	4.09	-1.76	8.4	300.	S
37	18.0	1926.	4.31	-1.87	8.1	299.	S
38	18.5	1980.	4.57	-1.98	9.3	292.	S
39	19.0	2033.	4.82	-2.06	8.9	288.	S
40	19.5	2087.	5.10	-2.12	9.5	283.	S

NOTE: D=DOUBLE THEODOLITE BALLOON RUN
S=SINGLE THEODOLITE BALLOON RUN
M=DOUBLE THEO. RUN MISSED CONVERGING BY MORE THAN 10 METERS
I=INTERPOLATION MADE AT THIS LEVEL

BUTTE AIRPORT UPPER AIR SUMMARY

DATE: 790601 HOUR: 510

READING NO.	TIME ELAP (MIN)	TEMP (C)	HEIGHT (M ACL)	LAPSE RATE (C/100M)
1	0.0	-2.00	0.	0.0
2	0.5	0.50	54.	4.672
3	1.0	1.90	107.	2.617
4	1.5	2.20	161.	0.561
5	2.0	3.20	214.	1.869
6	2.5	3.80	268.	1.121
7	3.0	5.10	321.	2.430
8	3.5	5.60	375.	0.934
9	4.0	5.30	428.	-0.561
10	4.5	5.20	482.	-0.187
11	5.0	5.00	535.	-0.374
12	5.5	4.70	589.	-0.561
13	6.0	4.60	642.	-0.187
14	6.5	4.30	696.	-0.561
15	7.0	3.90	749.	-0.748
16	7.5	3.50	803.	-0.748
17	8.0	3.10	856.	-0.748
18	8.5	2.80	910.	-0.561
19	9.0	2.40	963.	-0.748
20	9.5	2.00	1017.	-0.748
21	10.0	1.60	1070.	-0.748
22	10.5	1.10	1124.	-0.934
23	11.0	0.80	1177.	-0.561
24	11.5	0.40	1231.	-0.748
25	12.0	0.20	1284.	-0.374
26	12.5	0.0	1338.	-0.374
27	13.0	-0.30	1391.	-0.561
28	13.5	-0.70	1445.	-0.748
29	14.0	-1.10	1498.	-0.748
30	14.5	-1.50	1552.	-0.748
31	15.0	-1.90	1605.	-0.748
32	15.5	-2.20	1659.	-0.561
33	16.0	-2.60	1712.	-0.748
34	16.5	-2.90	1766.	-0.561
35	17.0	-3.20	1819.	-0.561
36	17.5	-3.40	1873.	-0.374
37	18.0	-3.80	1926.	-0.748
38	18.5	-3.80	1980.	0.0
39	19.0	-3.90	2033.	-0.187
40	19.5	-4.10	2087.	-0.374
41	20.0	-4.40	2140.	-0.561

BUTTE AIRPORT UPPER AIR SUMMARY

DATE: 790601 HOUR: 510

HOLZWORTH CLASSIFICATION SCHEME FOR INVERSIONS

NV.	BASE(M AGL)	THICKNESS (M)	TYPE	DT/DZ (C/100M)
	C.C	374.5	3	2.029

ORNING MIXING HEIGHT: 52.9 M
AVERAGE WIND SPEED THRU MIXED LAYER: 1.5 M/SEC

WIND SPEED AND DIRECTION SUMMARY

HEIGHT (M)	WIND SPD (M/SEC)	WIND DIR (DEG)
SFC	0.9	180.
100.	1.5	180.
200.	1.2	277.
300.	0.3	258.
500.	0.9	302.
750.	3.5	278.
1000.	4.8	297.
1500.	7.4	295.
2000.	9.3	292.

APPENDIX B - MODEL INPUT DATA PREPARATION PROGRAMS

METEOROLOGY STAR DECK PROGRAM ("AIRSTARV")

USER MANUAL

Prepared by: Thomas G. Stewart P.E.
Consultant

Prepared for: Department of Health and Environmental Sciences
Air Quality Bureau

PROGRAM "AIRSTARV"

Wind-Stability Frequency Deck

This program produces a summary report and a card deck of wind-stability decimal frequencies which are formatted for input data as required by the valley (CDM and CDNQC) and Climatological Dispersion model program (CDM and CDNQC). This deck is commonly referred to as the "star deck" and is similar to data produced by the star program available from the National Climatic Center.

In detail the star deck contains decimal frequencies of occurrence for 576 possible combinations of wind speed, wind direction and atmospheric stability.

There are 96 cards in the deck. Each card contains 6 values representing frequencies for the established wind speed categories 0.76, 2.45, 4.47, 6.93, 9.61 and 12.52 m/s respectively. The first set of 16 cards represent the 16 wind rose directions and in total this set represents stability Class A. This is followed by 5 more sets of 16 cards representing stability Classes B, C, D, E and F respectively.

The format of each of the six values/card satisfies the Fortran F field specification 6(F5.3).

The wind and stability data used as input to produce the star deck are stored on the AQDHS data bank. The user retrieves the desired data from AQDHS using the standard retrieval procedure (see user manual for the Montana AQDHS system). The retrieved data is written on magtape which is then sorted

chronologically. The sorted file becomes the required input to this program.

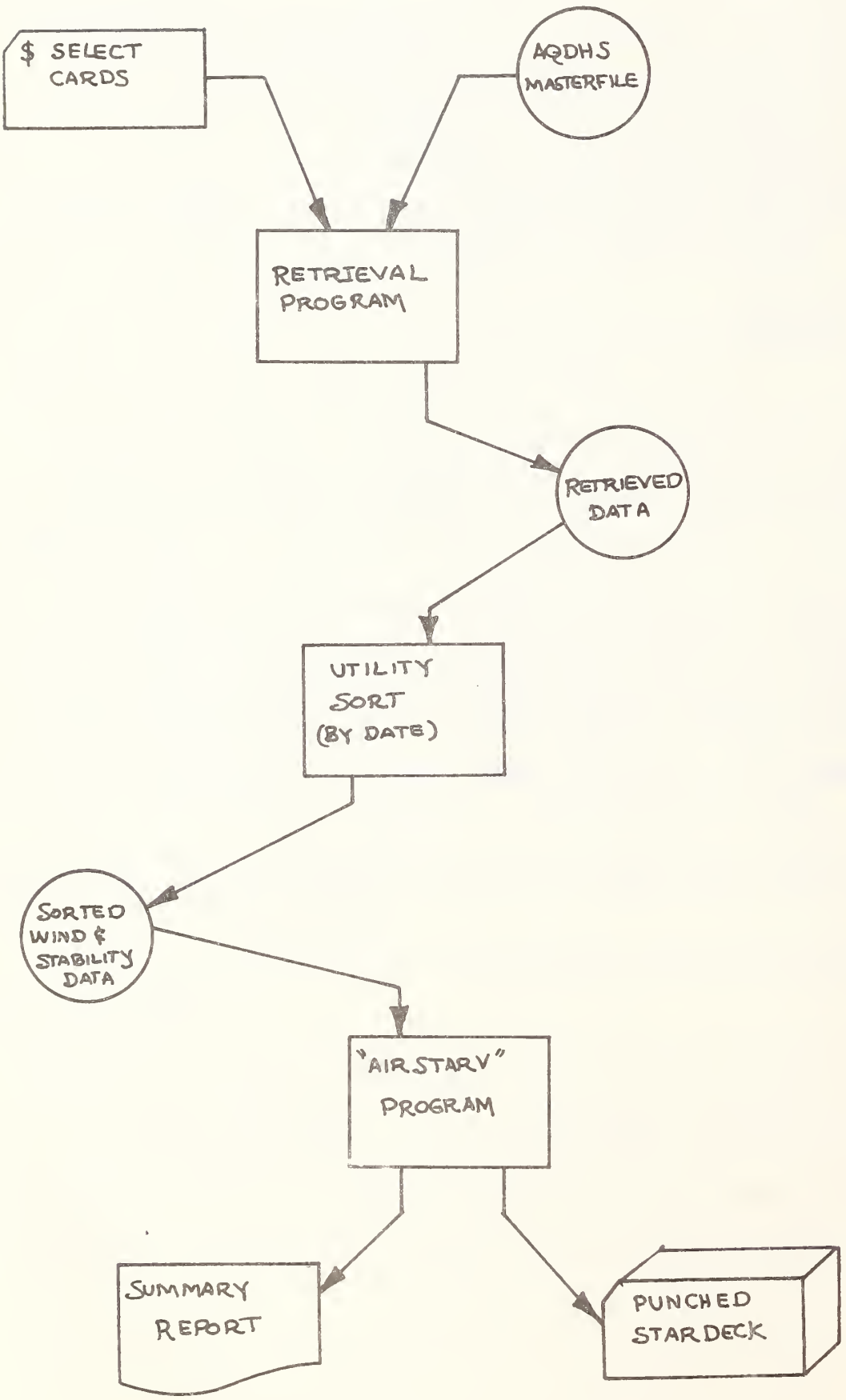
The wind data available on AQDHS for a given site location may consist of three different types. The method code keys the type and they are: 20 (NWS visual observation), 40 (Instrumental (visual average)) and 50 (Instrumental (electronic average)). All wind speeds have the parameter code 61101 and all wind directions have the parameter code 61102. The stability data is stored with parameter code 61501.

When retrieving the data from AQDHS the user should specify only the parameter codes. This will cause all wind data having method codes 20, 40 and 50 to be retrieved.

The program is written to accept all three types. This was to allow developing a star deck with as much data as possible resulting in more representative meteorological input to the models. Wind data available under method code 40 is given precedence over the others for a given hour. If Method Code 40 data is missing then Method Code 50 data is used and finally if method code 50 data is missing then method code 20 data is used. The summary report indicates the percentage of each type that was used in the star deck generated. An example summary report is attached to this report.

The program will accept data for a given site for any time span desired by the user.

DATA FLOW THROUGH SYSTEM



EXAMPLE SUMMARY REPORT

STABILITY WIND ROSE DATA GENERATION SUMMARY

STATE-CODE: 27 AREA-CODE: 0340 SITE-CODE: 001

START DATE OF INPUT DATA: 01/01/78

END DATE OF INPUT DATA: 12/31/78

STABILITY CLASS A

DIR.	WIND SPEEDS METERS/SECOND					
	0.67	2.45	4.47	6.93	9.61	12.52
N	0.000	0.000	0.000	0.000	0.000	0.000
NNE	0.000	0.000	0.000	0.000	0.000	0.000
NE	0.000	0.000	0.000	0.000	0.000	0.000
ENE	0.000	0.000	0.000	0.000	0.000	0.000
E	0.000	0.000	0.000	0.000	0.000	0.000
ESE	0.000	0.000	0.000	0.000	0.000	0.000
SE	0.000	0.001	0.000	0.000	0.000	0.000
SSE	0.000	0.000	0.000	0.000	0.000	0.000
S	0.000	0.000	0.000	0.000	0.000	0.000
SSW	0.000	0.000	0.000	0.000	0.000	0.000
SW	0.000	0.001	0.000	0.000	0.000	0.000
WSW	0.000	0.000	0.000	0.000	0.000	0.000
W	0.000	0.000	0.000	0.000	0.000	0.000
WNW	0.000	0.000	0.000	0.000	0.000	0.000
NW	0.000	0.000	0.000	0.000	0.000	0.000
NNW	0.000	0.000	0.000	0.000	0.000	0.000

STABILITY CLASS B

DIR.	WIND SPEEDS METERS/SECOND					
	0.67	2.45	4.47	6.93	9.61	12.52
N	0.001	0.000	0.000	0.000	0.000	0.000
NNE	0.000	0.000	0.000	0.000	0.000	0.000
NE	0.001	0.000	0.000	0.000	0.000	0.000
ENE	0.001	0.000	0.000	0.000	0.000	0.000
E	0.000	0.000	0.000	0.000	0.000	0.000
ESE	0.000	0.000	0.000	0.000	0.000	0.000
SE	0.000	0.000	0.000	0.000	0.000	0.000
SSE	0.001	0.000	0.000	0.000	0.000	0.000
S	0.003	0.000	0.000	0.000	0.000	0.000
SSW	0.001	0.000	0.000	0.000	0.000	0.000
SW	0.001	0.000	0.000	0.000	0.000	0.000
WSW	0.000	0.000	0.000	0.000	0.000	0.000
W	0.001	0.000	0.000	0.000	0.000	0.000
WNW	0.001	0.000	0.000	0.000	0.000	0.000
NW	0.001	0.000	0.000	0.000	0.000	0.000
NNW	0.001	0.000	0.000	0.000	0.000	0.000

STABILITY CLASS C

DIR.	WIND SPEEDS METERS/SECOND					
	0.67	2.45	4.47	6.93	9.61	12.52
N	0.001	0.004	0.011	0.002	0.001	0.000
NNE	0.000	0.003	0.004	0.000	0.000	0.000
NE	0.000	0.002	0.001	0.000	0.000	0.000
ENE	0.000	0.001	0.001	0.000	0.000	0.000
E	0.000	0.001	0.002	0.003	0.001	0.000
ESE	0.000	0.001	0.002	0.003	0.001	0.000
SE	0.000	0.003	0.003	0.005	0.002	0.000
SSE	0.000	0.002	0.004	0.006	0.001	0.000
S	0.000	0.004	0.006	0.002	0.001	0.000
SSW	0.001	0.002	0.005	0.003	0.000	0.000
SW	0.000	0.003	0.006	0.007	0.001	0.000

WSW	0.000	0.001	0.004	0.006	0.003	0.001
W	0.000	0.007	0.008	0.011	0.005	0.001
WNW	0.001	0.003	0.008	0.005	0.005	0.001
NW	0.001	0.008	0.011	0.006	0.002	0.000
NNW	0.000	0.003	0.008	0.001	0.000	0.000

STABILITY CLASS D

DIR.	WIND SPEEDS METERS/SECOND					
	0.67	2.45	4.47	6.93	9.61	12.52
N	0.003	0.006	0.009	0.003	0.000	0.000
NNE	0.002	0.002	0.002	0.003	0.000	0.000
NE	0.003	0.003	0.003	0.001	0.001	0.000
ENE	0.001	0.003	0.001	0.003	0.000	0.000
E	0.001	0.004	0.003	0.001	0.000	0.000
ESE	0.001	0.001	0.002	0.001	0.000	0.000
SE	0.002	0.001	0.001	0.002	0.000	0.000
SSE	0.001	0.002	0.000	0.000	0.000	0.000
S	0.003	0.005	0.004	0.002	0.000	0.000
SSW	0.002	0.004	0.002	0.001	0.000	0.000
SW	0.003	0.003	0.002	0.001	0.000	0.000
WSW	0.002	0.003	0.002	0.003	0.001	0.000
W	0.002	0.003	0.004	0.003	0.004	0.001
WNW	0.003	0.003	0.003	0.005	0.002	0.001
NW	0.001	0.007	0.011	0.008	0.002	0.001
NNW	0.003	0.007	0.009	0.005	0.002	0.000

STABILITY CLASS E

DIR.	WIND SPEEDS METERS/SECOND					
	0.67	2.45	4.47	6.93	9.61	12.52
N	0.005	0.003	0.001	0.000	0.000	0.000
NNE	0.005	0.001	0.001	0.000	0.000	0.000
NE	0.004	0.001	0.002	0.001	0.000	0.000
ENE	0.003	0.003	0.005	0.000	0.001	0.001
E	0.004	0.007	0.005	0.001	0.000	0.000
ESE	0.004	0.005	0.007	0.001	0.000	0.000
SE	0.010	0.009	0.006	0.001	0.000	0.000
SSE	0.008	0.006	0.005	0.001	0.000	0.000
S	0.012	0.013	0.008	0.001	0.000	0.000
SSW	0.005	0.006	0.005	0.001	0.000	0.000
SW	0.005	0.004	0.005	0.004	0.001	0.000
WSW	0.002	0.006	0.008	0.008	0.004	0.000
W	0.001	0.007	0.012	0.012	0.004	0.004
WNW	0.004	0.005	0.010	0.009	0.005	0.002
NW	0.008	0.007	0.006	0.002	0.001	0.001
NNW	0.004	0.003	0.002	0.000	0.000	0.000

STABILITY CLASS F

DIR.	WIND SPEEDS METERS/SECOND					
	0.67	2.45	4.47	6.93	9.61	12.52
N	0.007	0.000	0.000	0.000	0.000	0.000
NNE	0.004	0.000	0.000	0.000	0.000	0.000
NE	0.004	0.000	0.000	0.000	0.000	0.000
ENE	0.003	0.000	0.000	0.000	0.000	0.000
E	0.005	0.002	0.001	0.000	0.000	0.000
ESE	0.003	0.005	0.000	0.000	0.000	0.000
SE	0.011	0.010	0.000	0.000	0.000	0.000
SSE	0.006	0.009	0.001	0.000	0.000	0.000
S	0.015	0.017	0.002	0.000	0.000	0.000
SSW	0.008	0.008	0.000	0.000	0.000	0.000
SW	0.005	0.005	0.001	0.000	0.000	0.000
WSW	0.004	0.006	0.002	0.000	0.000	0.000
W	0.002	0.006	0.001	0.000	0.000	0.000
WNW	0.002	0.002	0.000	0.000	0.000	0.000
NW	0.009	0.008	0.001	0.000	0.000	0.000
NNW	0.008	0.002	0.000	0.000	0.000	0.000

STABILITY WIND ROSE DATA GENERATION SUMMARY

STATE-CODE: 27 AREA-CODE: 0340 SITE-CODE: 001

START DATE OF INPUT DATA: 01/01/78

END DATE OF INPUT DATA: 12/31/78

365 = NO. OF DAYS WHICH HAD SOME DATA

0 = NO. OF HOURS OF METHOD 20 WIND DATA USED IN STAR DECK

4014 = NO. OF HOURS OF METHOD 40 WIND DATA USED IN STAR DECK

0 = NO. OF HOURS OF METHOD 50 WIND DATA USED IN STAR DECK

2817 = NO. OF HOURS NOT USED DUE TO MISSING STABILITY DATA

1805 = NO. OF HOURS NOT USED DUE TO MISSING WIND DATA

31 = NO. OF HOURS NOT USED DUE TO MISSING WIND AND STABILITY DATA

93 = NO. OF HOURS NOT USED DUE TO ZERO WINDSPEED

4014 = TOTAL NO. OF HOURS USED IN GENERATED STAR DECK

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"PRECRSTER" PROGRAM

USER MANUAL

A Preprocessor Program which prepares AQDHS meteorology data for the single source air dispersion model (CRSTER)

Prepared by: Thomas G. Stewart, P.E.
Consultant

For: Department of Health and Environmental Sciences
Air Quality Bureau

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Introduction

The program "PRECRSTER" was developed to prepare meteorology data from the Air Quality Bureau's AQDHS data bank for input to the "Single-source (CRSTER)" air dispersion computer model. The model was obtained from EPA along with their own preprocessor program. The "PRECRSTER" program replaces the preprocessor portion of their package.

This program allows use of more detailed and current meteorology data which is important in obtaining accurate results in pollution diffusion models. The preprocessor supplied with the model is designed to use 1964 data recorded by the National Weather Service. The few scattered weather stations in Montana do not have data representing meteorology conditions near most areas being modeled.

The details of the method to prepare the meteorological data used in this program are given in the next section.

Method Used

EPA's CRSTER model requires input of meteorology data for every hour of the day for all days in one full year. Even though the model requires a full year of data, the user may choose by setting parameters for the model any one or a selected group of days to study. It is possible that some days for a particular site have missing data and this program fills the missing days with dummy values. A summary report flags these missing days with 0s whereas 1s indicate that a full day of meteorology data is available. It is the user's responsibility to choose days for which data are available when making a model study.

The meteorology data file from this program includes hourly wind speed, wind direction, stability class, temperature and mixing height. This data is

retrieved from AQDHS and processed with interpolation if necessary into an output tape file formatted for input to the model.

The data retrieved for a given site from the AQDHS data bank is detailed below.

	PARAMETER CODE	METHOD CODE	UNITS CODE	DEC POSITION	TIME INTERVALS AVAILABLE
Wind Speed	61101	20	11	1	3 hours
	61101	40	12	1	1 hour
	61101	50	11	2	1 hour
Wind Direction	61102	20	14	0	3 hours
	61102	40	14	0	1 hour
	61102	50	14	0	1 hour
Stability	61501	11	59	0	2 hours
Mixing Height	61401	11	57	0	6 hours
Temperature	62101	20	26	0	3 hours

Where: Method 20 = NWS (Visual observation)
Method 40 = Visual average (Instrumental)
Method 50 = Electronic average (Instrumental)

Units 11 = m/sec
12 = miles/hour (converted to m/sec by program)
14 = degrees
59 = unitless: stability Class A=1, B=2, C=3, D=4, E=5, F=6
57 = meters
26 = Rancine (converted to Kelvin by programs)

All data fields on AQDHS records are 4 digit fields with Dec position noted as above.

The above data is retrieved using the standard retrieval procedure (see User manual for the Montana AQDHS system). The retrieved data is then sorted chronologically before inputting to this program. The wind data available for a given site may consist of the three different types as shown above. The user should specify in his select cards only the parameter codes. This will

cause all available wind data to be retrieved regardless of method. This program is written to accept all 3 methods which allow generating as many full days as possible for the model studies. Method 40 is considered to be the most accurate wind data and if available is used (for the full day) in preference to methods 50 and 20. If method 40 data is missing then 50 is used, and method 20 is used if method 50 is missing.

Temperature data are available only at the NWS sites, so data for the station nearest to the study area is retrieved and may not be representative, but would be acceptable since the relative influence of temperature and the model's accuracy is small. The program will allow only one missing data value between values for the given parameter and linearly interpolates a value (or values) in its place. For example, if a 3-hour interval data value is missing at say 1100 hours, the interpolated values for 900, 1000, 1100 12,00 and 1300 hours are calculated. The program extrapolates on either end should the first or last interval hour of the 24-hour period be missing. It might be more accurate to use the day before or the day after allowing interpolation for these cases, but it was decided that since the data for these days may be missing, the result would be fewer full days of generated data for the model, to say nothing of the greatly increased programming logic complications. The mixing height data is an exception to the above rules, in that if one of the four possible readings for the day is missing, all data for the day are thrown out.

The summary report printed by the program indicates the full days of meteorological data written to the tape file and a count of the days which had insufficient data in each type to enable generating a full day.

The format of the meteorology data written to tape for input to the CRSTER model is given in the following table:

PREPROCESSOR OUTPUT FILE RECORD DESCRIPTION

Position of Variable Within the Record	Variable Name	Fortran Variable Type	
1	IYEAR	INTEGER	Year of record (last two digits)
2	IMONTH	INTEGER	Month
3	DAY1	REAL	Day of month
4-27	KST	INTEGER	Array of 24 Stability Class Values
28-51	SPEED	REAL	Array of 24 Wind Speed Values (ms^{-1})
52-75	TEMP	REAL	Array of 24 Ambient Temperature Values (°K)
76-99	AFV	REAL	Array of 24 Flow Vector Values (degrees)
100-123	FVR	REAL	Array of 24 Randomized Flow Vectors (degrees)
124-171	HLH	REAL	Array dimensioned 2 by 24 containing 24 rural mixing height values and 24 urban mixing height values (m). The values are stored on the record in groups of two for each hour with the rural mixing height first followed by the urban mixing height for that hour.

Note: 1. The compliment of the AQDHS wind direction is made by the program for the 24 flow vectors.

2. Since it's anticipated that the relatively accurate method 40 wind data will be available more frequently than the others, the wind direction was not randomized. Therefore, the randomized flow vector values are the same as the flow vectors described above.

3. No special treatment was made to the AQDHS mixing heights for urban and rural and they are made the same on the output tape. It's anticipated that the model will be used as a screening model using a rural mode.

The tape is written with unformatted write statements to make it compatible with the corresponding unformatted read statements in the CRSTER model program.

The first record of the output tape contains four values written also with an unformatted write statement and are in the order given below.

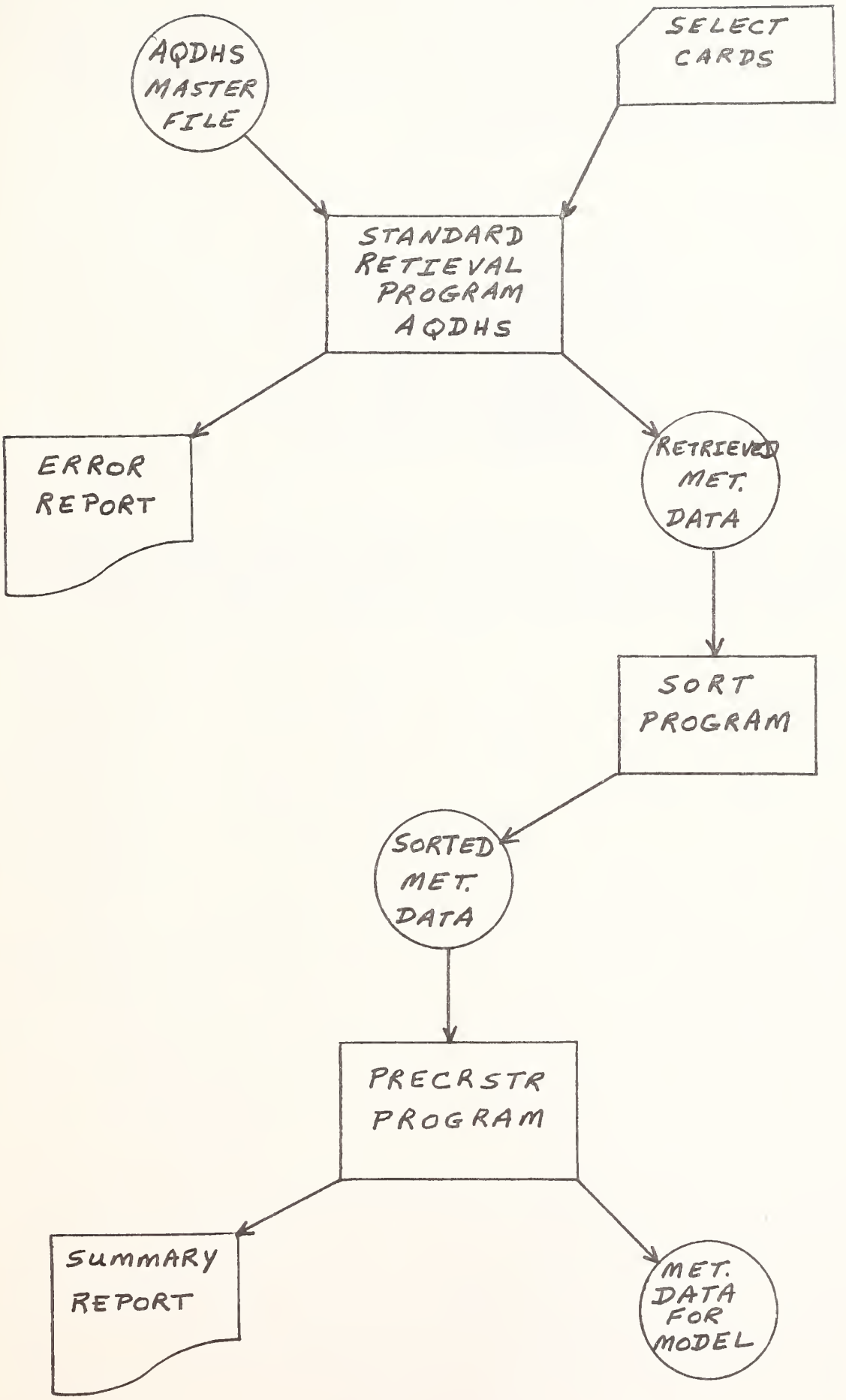
1. Area - code
2. Year of record
3. Area - code
4. Year of record

Note that 1 and 2 are the same as 3 and 4. The program writes this record essentially to meet input requirements to the model. It was generated by EPA's preprocessor program to describe NWS surface station number for 1 and the upper air station number for 3.

How to Run the Program

The program requires one magnetic tape as input. This tape is the desired meteorology data (for a given year) retrieved from the AQDHS-Data Bank and sorted in ascending order by date.

The following is a schematic of the flow of data through the system.


AQDHS MASTER FILE
SELECT CARDS
STANDARD RETIEVAL PROGRAM AQDHS
ERROR REPORT
RETRIEVED MET. DATA
SORT PROGRAM
SORTED MET. DATA
PRECRSTR PROGRAM
SUMMARY REPORT
MET. DATA FOR MODEL

The user must decide upon a site representative of the meteorology condition for the study area and which has sufficient data available for it on the AQDHS data bank. The user should then punch a set of select cards according to the rules for making a standard retrieval request (see AQDHS user's manual). The following is an example set:

```
$ Select

Area-Code              = '0340'      and
Site-Code              = ' 001'      and
Year                   = '79'        and
Parameter-Code         = '61101'     or
Parameter-Code         = '61102'     or
Parameter-Code         = '61501'     or
Parameter-Code         = '61401'     or
Parameter-Code         = '62101'

$ END
```

The above selection will retrieve all data for Area 0340 site 001 for the year 79 having parameter codes 61101 or 61102 or 61501 or 61401 or 62101.

APPENDIX C

EXAMPLE DATA REPORT FROM AQDHS

EXAMPLE STAR FREQUENCY LISTING
FROM AIRSTARV

EXAMPLE DIFFUSION MODEL OUTPUT
USING THE STAR FREQUENCY

STATE OF MONTANA - DEPARTMENT OF HEALTH AND ENVIRONMENTAL SCIENCES
AIR QUALITY DATA REPORT

REPORT DATE: 07/16/79 PAGE 6

PARAMETER: SUSPENDED PARTICULATE (11101) UNITS: MICROGRAMS/CUBIC METER (01) MIN DET: 1 DECIMAL CODE: 0
COLLECTION METHOD: HI-VOL (91) ANALYSIS METHOD: GRAVIMETRIC SAMPLING INTERVAL: DAILY

SITE: MCCONE CO - FORT PECK - HIVOL,WIND,BUBBLER,MEMBRANE (0980-001) AGENCY: STATE (F)
PROJECT: BACKGROUND SURVEILLANCE (03) YEAR: 1978 MONTH:

MONTANA STANDARD: 000200MICROGRAMS/CUBIC METER-24 HR MAX-1% OF TIME
FEDERAL PRIMARY STANDARD: 000260MICROGRAMS/CUBIC METER-24 HR MAX-1 PER YEAR
FEDERAL SECONDARY STANDARD: 000150MICROGRAMS/CUBIC METER-24 HR MAX-1 PER YEAR

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	NO.	MEAN	MAX
01		3				12	18						3	11	18
02	7			6	19								3	11	19
03			8										1	8	8
04											17	4	2	11	17
05									58	8			2	33	58
06								39					1	39	39
07							30						1	30	30
08	7			7	9								3	6	9
09			7										1	7	7
10											2	4	2	3	4
11									48	17			2	33	48
12								26					1	26	26
13		13				17	19						3	16	19
14	5			17	19								3	14	19
15															
16											13		1	13	13
17									18				1	18	18
18								24					1	24	24
19		6				20	22						3	16	22
20					41								1	41	41
21			7										1	7	7
22											12	3	2	8	12
23									6				1	6	6
24								30					1	30	30
25		5											1	5	5
26	6			37	25								3	23	37
27			6										1	6	6
28											4	6	2	5	6
29									22	16			2	19	22
30								39					1	39	39
31							15						1	15	15
NO	4	4	4	4	5	3	5	5	5	3	5	4	51		
MEAN	6	7	7	17	23	16	21	32	30	14	10	4		16	
MAX	7	13	8	37	41	20	30	39	58	17	17	6			58

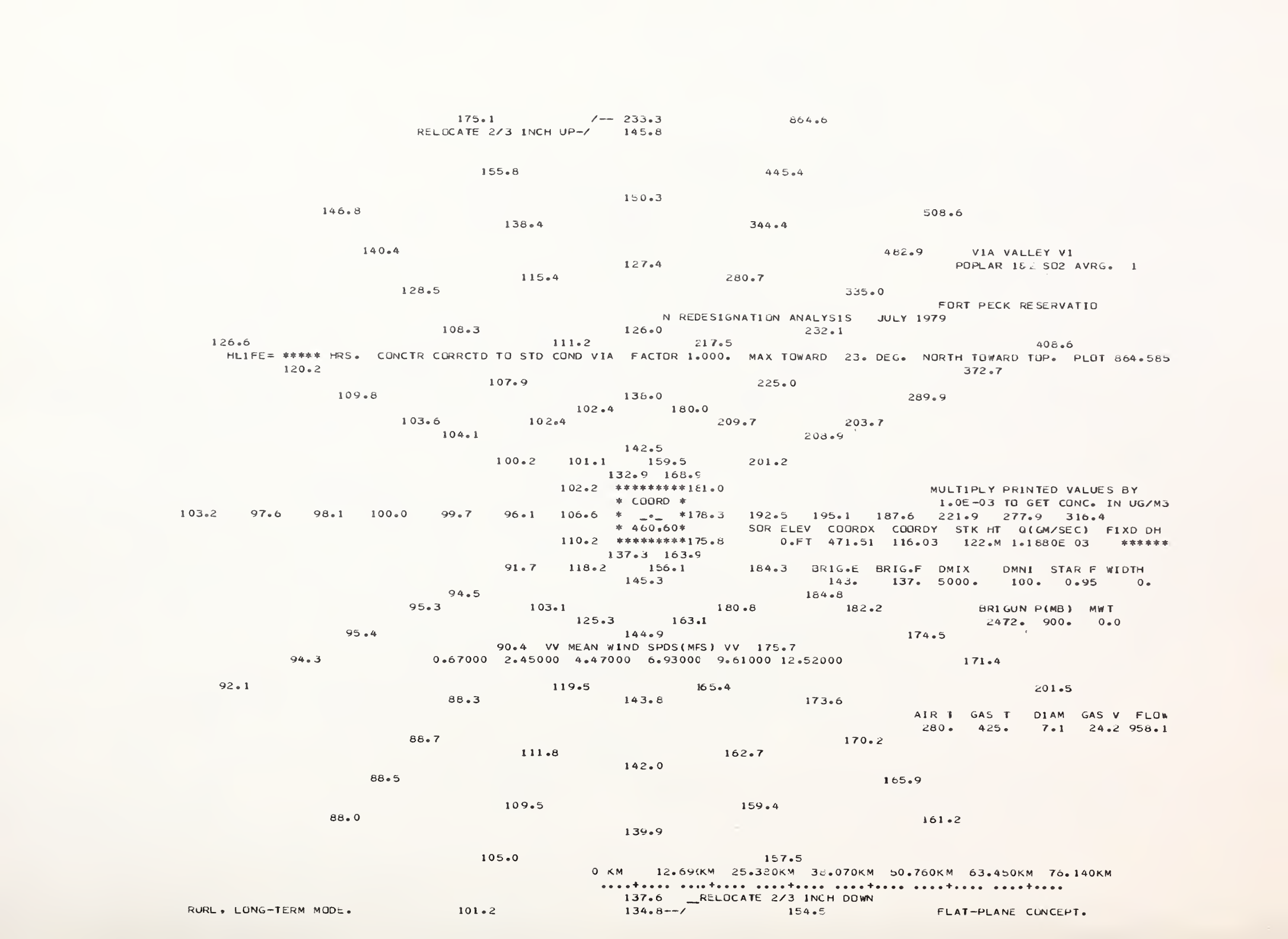
NUMBER OF TIMES ABOVE MONTANA VALUE: 0
NUMBER OF TIMES ABOVE FEDERAL PRIMARY VALUE: 0
NUMBER OF TIMES ABOVE FEDERAL SECONDARY VALUE: 0

****

FORT PECK RESERVATION REDESIGNATION ANALYSIS JULY 1979

STABILITY	SPD(MPS) WIND DIR	0.670	2.450	4.470	6.930	9.610	12.520
A	N	0.0	0.0	0.0	0.0	0.0	0.0
A	NNE	0.0	0.0	0.0	0.0	0.0	0.0
A	NE	0.0	0.0	0.0	0.0	0.0	0.0
A	ENE	0.0	0.0	0.0	0.0	0.0	0.0
A	E	0.0	0.0	0.0	0.0	0.0	0.0
A	ESE	0.0	0.0	0.0	0.0	0.0	0.0
A	SE	0.0	0.0010	0.0	0.0	0.0	0.0
A	SSE	0.0	0.0	0.0	0.0	0.0	0.0
A	S	0.0	0.0	0.0	0.0	0.0	0.0
A	SSW	0.0	0.0	0.0	0.0	0.0	0.0
A	SW	0.0	0.0010	0.0	0.0	0.0	0.0
A	WSW	0.0	0.0	0.0	0.0	0.0	0.0
A	W	0.0	0.0	0.0	0.0	0.0	0.0
A	WNW	0.0	0.0	0.0	0.0	0.0	0.0
A	NW	0.0	0.0	0.0	0.0	0.0	0.0
A	NNW	0.0	0.0	0.0	0.0	0.0	0.0
B	N	0.0010	0.0	0.0	0.0	0.0	0.0
B	NNE	0.0	0.0	0.0	0.0	0.0	0.0
B	NE	0.0010	0.0	0.0	0.0	0.0	0.0
B	ENE	0.0010	0.0	0.0	0.0	0.0	0.0
B	E	0.0	0.0	0.0	0.0	0.0	0.0
B	ESE	0.0	0.0	0.0	0.0	0.0	0.0
B	SE	0.0	0.0	0.0	0.0	0.0	0.0
B	SSE	0.0010	0.0	0.0	0.0	0.0	0.0
B	S	0.0030	0.0	0.0	0.0	0.0	0.0
B	SSW	0.0010	0.0	0.0	0.0	0.0	0.0
B	SW	0.0010	0.0	0.0	0.0	0.0	0.0
B	WSW	0.0	0.0	0.0	0.0	0.0	0.0
B	W	0.0010	0.0	0.0	0.0	0.0	0.0
B	WNW	0.0010	0.0	0.0	0.0	0.0	0.0
B	NW	0.0010	0.0	0.0	0.0	0.0	0.0
B	NNW	0.0010	0.0	0.0	0.0	0.0	0.0
C	N	0.0010	0.0040	0.0110	0.0020	0.0010	0.0
C	NNE	0.0	0.0030	0.0040	0.0	0.0	0.0
C	NE	0.0	0.0020	0.0010	0.0	0.0	0.0
C	ENE	0.0	0.0010	0.0010	0.0	0.0	0.0
C	E	0.0	0.0010	0.0020	0.0030	0.0010	0.0
C	ESE	0.0	0.0010	0.0020	0.0030	0.0010	0.0
C	SE	0.0	0.0030	0.0030	0.0050	0.0020	0.0
C	SSE	0.0	0.0020	0.0040	0.0060	0.0010	0.0
C	S	0.0	0.0040	0.0060	0.0020	0.0010	0.0
C	SSW	0.0010	0.0020	0.0050	0.0030	0.0	0.0
C	SW	0.0	0.0030	0.0060	0.0070	0.0010	0.0
C	WSW	0.0	0.0010	0.0040	0.0060	0.0030	0.0010
C	W	0.0	0.0070	0.0080	0.0110	0.0050	0.0010
C	WNW	0.0010	0.0030	0.0080	0.0050	0.0050	0.0010
C	NW	0.0010	0.0080	0.0110	0.0060	0.0020	0.0
C	NNW	0.0	0.0030	0.0080	0.0010	0.0	0.0

D	N	0.0030	0.0060	0.0090	0.0030	0.0	0.0
D	NNE	0.0020	0.0020	0.0020	0.0030	0.0	0.0
D	NE	0.0030	0.0030	0.0030	0.0010	0.0010	0.0
D	ENE	0.0010	0.0030	0.0010	0.0030	0.0	0.0
D	E	0.0010	0.0040	0.0030	0.0010	0.0	0.0
D	ESE	0.0010	0.0010	0.0020	0.0010	0.0	0.0
D	SE	0.0020	0.0010	0.0010	0.0020	0.0	0.0
D	SSE	0.0010	0.0020	0.0	0.0	0.0	0.0
D	S	0.0030	0.0050	0.0040	0.0020	0.0	0.0
D	SSW	0.0020	0.0040	0.0020	0.0010	0.0	0.0
D	SW	0.0030	0.0030	0.0020	0.0010	0.0	0.0
D	WSW	0.0020	0.0030	0.0020	0.0030	0.0010	0.0
D	W	0.0020	0.0030	0.0040	0.0030	0.0040	0.0010
D	WNW	0.0030	0.0030	0.0030	0.0050	0.0020	0.0010
D	NW	0.0010	0.0070	0.0110	0.0080	0.0020	0.0010
D	NNW	0.0030	0.0070	0.0090	0.0050	0.0020	0.0
E	N	0.0050	0.0030	0.0010	0.0	0.0	0.0
E	NNE	0.0050	0.0010	0.0010	0.0	0.0	0.0
E	NE	0.0040	0.0010	0.0020	0.0010	0.0	0.0
E	ENE	0.0030	0.0030	0.0050	0.0	0.0010	0.0010
E	E	0.0040	0.0070	0.0050	0.0010	0.0	0.0
E	ESE	0.0040	0.0050	0.0070	0.0010	0.0	0.0
E	SE	0.0100	0.0090	0.0060	0.0010	0.0	0.0
E	SSE	0.0080	0.0060	0.0050	0.0010	0.0	0.0
E	S	0.0120	0.0130	0.0080	0.0010	0.0	0.0
E	SSW	0.0050	0.0060	0.0050	0.0010	0.0	0.0
E	SW	0.0050	0.0040	0.0050	0.0040	0.0010	0.0
E	WSW	0.0020	0.0060	0.0080	0.0080	0.0040	0.0
E	W	0.0010	0.0070	0.0120	0.0120	0.0040	0.0040
E	WNW	0.0040	0.0050	0.0100	0.0090	0.0050	0.0020
E	NW	0.0080	0.0070	0.0060	0.0020	0.0010	0.0010
E	NNW	0.0040	0.0030	0.0020	0.0	0.0	0.0
F	N	0.0070	0.0	0.0	0.0	0.0	0.0
F	NNE	0.0040	0.0	0.0	0.0	0.0	0.0
F	NE	0.0040	0.0	0.0	0.0	0.0	0.0
F	ENE	0.0030	0.0	0.0	0.0	0.0	0.0
F	E	0.0050	0.0020	0.0010	0.0	0.0	0.0
F	ESE	0.0030	0.0050	0.0	0.0	0.0	0.0
F	SE	0.0110	0.0100	0.0	0.0	0.0	0.0
F	SSE	0.0060	0.0090	0.0010	0.0	0.0	0.0
F	S	0.0150	0.0170	0.0020	0.0	0.0	0.0
F	SSW	0.0080	0.0080	0.0	0.0	0.0	0.0
F	SW	0.0050	0.0050	0.0010	0.0	0.0	0.0
F	WSW	0.0040	0.0060	0.0020	0.0	0.0	0.0
F	W	0.0020	0.0060	0.0010	0.0	0.0	0.0
F	WNW	0.0020	0.0020	0.0	0.0	0.0	0.0
F	NW	0.0090	0.0080	0.0010	0.0	0.0	0.0
F	NNW	0.0080	0.0020	0.0	0.0	0.0	0.0


175.1 /-- 233.3 864.6
RELOCATE 2/3 INCH UP-/ 145.8
155.8 445.4
150.3
146.8 508.6
138.4 344.4
140.4 482.9 VIA VALLEY V1
127.4 POPLAR 1&2 SO2 AVRG. 1
115.4 280.7
128.5 335.0
FORT PECK RESERVATIO
N REDESIGNATION ANALYSIS JULY 1979
108.3 126.0 232.1
126.6 111.2 217.5 408.6
HLIFE= ***** HRS. CONCTR CORRCTD TO STD COND VIA FACTOR 1.000. MAX TOWARD 23. DEG. NORTH TOWARD TOP. PLOT 864.585
120.2 372.7
107.9 225.0
109.8 136.0 289.9
102.4 180.0
103.6 102.4 209.7 203.7
104.1 208.9
142.5
100.2 101.1 159.5 201.2
132.9 168.9
102.2 *********181.0 MULTIPLY PRINTED VALUES BY
* COORD * 1.0E-03 TO GET CONC. IN UG/M3
103.2 97.6 98.1 100.0 99.7 96.1 106.6 * _.-_ *178.3 192.5 195.1 187.6 221.9 277.9 316.4
* 460.60* SOR ELEV COORDX COORDY STK HT Q(GM/SEC) FIXD DH
110.2 *********175.8 0.FT 471.51 116.03 122.M 1.1880E 03 ******
137.3 163.9
91.7 118.2 156.1 184.3 BRIG.E BRIG.F DMIX DMNI STAR F WIDTH
145.3 143. 137. 5000. 100. 0.95 0.
94.5 184.8
95.3 103.1 180.8 182.2 BRIGUN P(MB) MWT
125.3 163.1 2472. 900. 0.0
95.4 144.9 174.5
90.4 VV MEAN WIND SPDS(MFS) VV 175.7
94.3 0.67000 2.45000 4.47000 6.93000 9.61000 12.52000 171.4
92.1 119.5 165.4 201.5
88.3 143.8 173.6
AIR T GAS T DIAM GAS V FLOW
280. 425. 7.1 24.2 958.1
88.7 170.2
111.8 162.7
142.0
88.5 165.9
109.5 159.4
88.0 161.2
139.9
105.0 157.5
0 KM 12.690KM 25.380KM 38.070KM 50.760KM 63.450KM 76.140KM
....+.... ....+.... ....+.... ....+.... ....+.... ....+....
137.6 _RELOCATE 2/3 INCH DOWN
RURL. LONG-TERM MODE. 101.2 134.8--/ 154.5 FLAT-PLANE CONCEPT.